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M I N E R A L O G Y.

BY
RICHARD KIRWAN, Esq; F.R.S.



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P R E F A C E.

WHEN we consider the degree of excellence which many of the practical arts busied in the treatment of Minerals have reached in *England*, and also that in the merely speculative sciences, we are at least on a level with our neighbours on the continent, it cannot but be matter of surprize that, with respect to Mineralogy, the parent of these arts, they should stand confessedly superior to us. That this inferiority on our side does not originate in any want of ingenuity in our artists evidently appears by the masterly productions of a *Parker* and a *Wedgewood*. The true cause lies deeper. Mineralogy is an art, whose cultivation and improvement requires both speculation and practice: the mere theorist will never descend into the laborious details of the practical part, without due encouragement or a degree of enthusiasm, in a country devoted to politics rarely to be met with, and the practical artist seldom possesses those general principles of science and extensive acquaintance with the discoveries of his cotemporaries that are indispensably requisite to establish him on a footing of equality with them. On the continent Mineralogy is on a very different footing. In *Sweden* and *Germany* it is considered as a branch of science worthy of the atten-

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tion of government. There are colleges in which it is regularly taught; it forms a distinct and honourable profession, like that of the foldier, the merchant, or the barrister; its superior officers form a part of the administration of the state. Young students, fraught with the knowledge to be acquired in their own country, are sent abroad to glean all that can be collected from a more diversified view of nature, or a more improved practice of the arts. This example has been lately followed by the *French*, the *Russians*, and even the *Spaniards*.

The French have erected a Mineralogical School at *Paris*, to which a considerable pension is annexed. Subterraneous maps of the whole kingdom are now a tracing, and mineralogical voyages are from time to time undertaken at the public expence*. Chymistry, the Parent of Mineralogy, is cultivated by the most enlightened nations in *Europe*, and particularly in *France* with a degree of ardour that approaches to enthusiasm; it forms the favourite occupation, and even the most fashionable object of attention not only of the middling, but even of some in the highest ranks of society†.

In

* As that of Mr. *Jars*, &c.

† Among these we may reckon in *Russia* prince *Gallitzen*; in *Germany* count *Sickingen*; in *Italy* the counts *de Saluces* &c.

In *England*, on the contrary, (a country far richer than *France* in mineral productions) it receives no encouragement from the public, and few apply to it except gentlemen in the Medical Line, whose transient attention is soon diverted by their more direct occupations. The consequences are obvious. The grossest blunders are daily committed in working our mines and extracting our ores; insomuch, that learned foreigners have remarked that were it not for their superior excellence, and the cheapness of fuel, their extraction would infallibly be attended with loss †, and many useful substances are daily rejected as useless.

Sensible of our inferiority in this respect, and well acquainted with the cause of it, the zealous and learned Doctor *Shaw*, and our late eminent Chymist Dr. *Lewis*, have laboured to promote and facilitate the study of Chymistry among us, and for this purpose transferred into our own language the most considerable improvements made in their time

de Morozzo, and the marquis *de Gironi*, governor of *Leghorn*; in *Geneva* Mr. *de Saussure*; in *France* the dukes *de Chaulnes*, *Rocheboucault*, and *D'Ayen*; the counts *de Lauragais*, *la Garay*, *Milly*, *Tressan*, and *de la Tour d'Auvergne*; the marquisses *de Courtenvaux* and *de Courtivron*; the barons *d'Albach* and *de Servieres*; madame la *Présidente d'Arconville*; messieurs *Trudaine*, *Lavoisier*, *Montigny*, and above all, Mr. *de Morveau*, one of the first chymists of the age.

† *Ferber, Reife Derbyshire.*

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by foreigners. At a still later period Mr. *Keir* has poured upon us many valuable treasures in his excellent notes on Mr. *Maquer's* Chymical Dictionary, a work generally known, and equally esteemed; yet since this work appeared, (the last of any note among us) such rapid advances have been made in the mineralogical art in particular, that it has put on quite a new face. Several new semi-metals have been discovered, the number of primitive earths ascertained, many analyses accomplished heretofore attempted in vain, and the art itself of Mineral Analysis brought to a degree of certainty and precision of which it was scarcely thought capable. Actuated by the same views as the patriotic gentlemen just mentioned, I have endeavoured to collect in the ensuing treatise all that has been hitherto done in this science, with some few improvements of my own, modelled and digested in the method that seemed to me most useful.

The point which I principally laboured was not to present the reader with a minute detail of the various external appearances of minerals in various countries, nor of their situation, vicinity, or mixture with each other, circumstances ever contingent and fortuitous, much less to entertain him with prolix and plausible accounts of their origin, enquiries

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enquires which appear to me to belong to another branch of the science of fossils, viz. *Natural History*, but rather to determine the characters by which fossils are invariably and permanently distinguished from each other in all times and places. In a word, rather to define the *species* than describe the *individual*; even among these permanent characters I have, for the sake of brevity, omitted all, except the most obvious, a complete detail of them being in my opinion fitter for a treatise of Chymistry than of Mineralogy. The merit of this latter seeming to me to consist in presenting such *criteria* as may enable us to distinguish Minerals in the shortest, easiest, and surest manner; so that we may always apply the same names to the same substances, and being confident of speaking the same language, may always understand each other. What confusion hath heretofore arisen from the ambiguity of names is well known, and will, I fear, render many very interesting researches, even of modern date, intirely useless. Among these I shall only mention those of the celebrated *Canon Recupero*, who for many years, and with immense pains, has studied and described the Minerals in the neighbourhood of *Mount Ætna*, but committed such mistakes in their denomination as will, according to the remark of that excellent Mineralogist

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Mr. *Saussyre*, render his work, if ever it appears, absolutely unintelligible*.

Whether the characters of Minerals should be taken from external appearances only, or from their internal properties, as discovered by chymical agents, has long been controverted among Mineralogists; though, indeed, at present the controversy seems almost at an end from the universal approbation with which the system of the celebrated *Cronsted*, founded almost entirely on chymical characters as far as they were known in his time, has been received by all *Europe*. However, some able patrons of the former opinion have appeared of late, among whom I shall mention only Mr. *Werner* and Mr. *Romé de Lisle*.

Mr. *Werner* is the author of an excellent treatise written in the *German* language on the external characters of fossils. Mr. *Romé* has lately published a voluminous treatise on the external forms of crystals, under which title he comprehends all those fossils that are susceptible of a regular figure, all of which he pretends may be distinguished by the angles which their planes make with each other, if some heterogeneous matter be not contained in them; but supposing all this to

* *Voyages des Alps*, p. 67.

be true, what a vast variety of figures are not these crystals subject to from a variety of accidents? How many indeterminate and confused crystallizations reducible to no certain figure? By how many external accidents may not these figures, though originally perfect, be altered and modified? What shall we say of his *macles* or agglutinated crystals? of the conic, spheroidal, cylindrical shapes in which no angle can be discovered? and of the various amorphous appearances of most Minerals?

Mr. *Werner* has endeavoured to classify Minerals by the joint consideration of all their external properties, and yet, that even this re-union is insufficient to determine their nature, he himself gives us a clear proof in his notes on *Cronsted*, p. 217. There, on the faith of these characters, he ranges among *micas* a green foliated substance, which, being sent to Mr. *Bergman*, proved to be a compound of marine salt of copper and argillaceous earth, though the quantity sent him amounted but to one grain; so much surer are chymical tests! Every science must be founded on permanent principles. The only principles of this sort that Mineralogy affords are the relations of the bodies it considers with chymical agents. Without referring to these, it can be reckoned at most only a conjectural

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jectural art. This will plainly appear by examining each of the external characters in particular; namely, colour, transparency, or opacity, coherence, texture, shape, and specific gravity.

And first as to *colour*, Mr. *Werner* owns that white quartz, white lead ore, and white calcareous iron ore, have exactly the same *snow white* colour. Some species of the ores of iron, manganese, cobalt, and copper, the same *iron grey* colour, wolfram and blende the same *brownish black*, &c. in short it is well known, that the slightest change in the texture of bodies, frequently produces a considerable alteration in colour; thus a lump of cinnabar, whose colour is *dark red*, becomes of a beautiful *florid red*, by simply reducing it to a powder; besides it is difficult, if not impossible, to render the various shades of colour intelligible by any description.

Transparency and Opacity are qualities common to a vast variety of substances, different in all other respects. They are susceptible of numerous undiscrivable degrees, and discover at most the mode of union, not the substances united.

Coherence and hardness are properties equally ambiguous: with respect to earths and powdered

dered stones, their consideration is of no use, striking fire with steel, has often been given as a test of pure siliceous earths, but it is now known, that well baked clay, to say nothing of other compound substances, will exhibit the same appearance.

Texture, all its varieties as granular, lamellar, fibrous, scaly, equable, &c. are common to substances, widely different; thus the fibrous is found in some varieties of gypsum, in asbestos, shoerl, pumice, pyrites, antimony, hæmatites, malachite, cobalt, and arsenical ores, the scaly in lead and iron ores, mica, limestones, gypsum, the lamellar, granular, and equable, are still of wider extent.

Shape, the varieties of this even when regular and determinate, are endless, as may be seen in Mr. *De Lisle's* Treatise, and must be so, as they depend of various external accidents, thus he finds 32 varieties in the shape of calcareous spar, 14 in that of gypsum, 9 in that of fluor, 16 in that of quartz, besides its *monstrous* forms, equally regular as the rest, 19 in that of felt spar, &c. and not only the same specific substance is susceptible of various shapes, but various substances specifically different, assume the same shape. Thus the native calx of arsenic, blende, cinnabar, and grey copper ore, often appear in a tetrahædral form;

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form; common salt, fluor, zeolyte, galena, in a cubic, &c. if the nature of any substance could be determined by its form, it would undoubtedly be that of salts, yet there is scarce any of these which in different circumstances, may not assume a different figure; Mr. *Pott* assures us, that microcosmic salt assumes the figure of almost all other salts, nitre, vitriol, salammoniac, allum, glauher's salts, &c. 4 *Pott*, 49. According to *Maquer*, if sublimate corrosive be crystalized, by cooling it forms needles, but if by mere evaporation, cubes or lozenges. *Mem. Par.* 1755, p. 540. Digestive salt will form cubes if it be exactly neutral, but if the alkali predominates quadrangular prisms, common salt is generally looked upon as the most constant in its figure, yet Mr. *Cadet* has found it crystalized in needles, 9 *Mem. Scav. Etrang.* p. 555. and *Gerhard*, 4 *Berlin, Schrift.* 292. Very many, if not most of the mistakes to be found in chymical writers on salts, arose from their having denominated them from their figure.

Lastly, *Specific Gravity*, which is certainly one of the best external tests, frequently varies, by reason either of the different texture of the same species of mineral, into whose interstices water cannot equally penetrate, or by reason of the greater proportion of some
or

or other of the constituent parts, as is particularly observable in zeolytes, which differ exceedingly in the proportion of water which enters into them as one of their constituent principles: also in the sparry or calcareous iron ore, whose proportion of calcareous earth is subject to great variation; besides all this, various substances specifically different, possess very nearly the same specific gravity.

Nevertheless I am far from asserting, that the consideration of mere external properties is intirely usefess; on the contrary, I am persuaded that from the consideration of these alone, a very probable conjecture may be drawn in most cases concerning the nature of fossils, whose specific properties are already known by analysis, but this conjecture must be formed by an experienced eye: for it is not possible by any description, to convey an adequate idea of those minute differences, or as I may say, the *physiognomies* of fossils, by which alone they are distinguishable. On this account I have been very succinct in this particular, rather hoping to help, than expecting to form the *coup d'œil*. Those who love to amuse themselves with a detailed description of these external forms, may consult with advantage Mr. *Romé de Lisle's* improved edition of his *Crystallographie* *, though daily expe-

* Or the improved edition of *Cronsted*, which Mr. *Magellan* promises soon to publish.

rience evinces, that nature is still more varied than his descriptions.* But where any *new* substance occurs, or an intire certainty required, such as constitutes the foundation of a *science*, there chymical tests are absolutely requisite, and alone sufficient. Thus neglecting these, Mr. *Romé de Lisle* took that to be a zeolyte which Mr. *Pelletier* afterwards found to be an ore of zinc. 2 *Crystallogr.* p. 46, 20 *Roz.* 424.

Mineralogy must therefore, on the whole, be considered as a branch of Chymistry, and its progress, like that of other branches of that science, has been for many ages scarce sensible. In the earliest times, of which we have any account in history, mankind seem to have been of the same turn of thinking as the less enlightened and civilized nations of our own age. Satisfied with such information as casual experience threw in their way, they regarded the occupation of consulting nature by experiment as a childish, trifling and useless amusement, and neglected forming any theory whatsoever concerning its operations; but in succeeding times the generalizing spirit of Aristotelic Metaphysics extending itself to Natural Philosophy, soon suggested the notion of one common matter

* See *Roz.* journal for March, 1784, p. 206, 207, and 211.
being

being the *substratum* of all vegetable, animal and mineral substances, discriminated only by particular forms, which in the two former were held to be *substantial*, and in the latter purely accidental. From this ungrounded opinion (to which however some of the greatest men in the last century were much attached) that of the transmutability of metals into each other naturally arose; and to this notion, and some other equally false, the progress of Mineralogy, and every branch of Chymistry, is undoubtedly owing. To accomplish their favourite purpose experiments were multiplied without end, and by means of these the arts of dying, pottery, glass-making and metallurgy were insensibly improved.

The two last named arts necessarily required some knowledge of the chymical properties of stones and earths. Accordingly we find that all those that were useful in the former were called *vitriifiable*; those that were capable of burning to lime *calcareous*, and those on which fire could produce neither effect, *apyrrous*. For a long time these three divisions were thought to comprehend all species of earths and stones. The same narrow spirit of referring every thing to what is already known, induced Mineralogists to class all metallic substances under some of the species

cies antiently known, denominating all those which discovered any singular properties *wild, rapacious and arsenical compounds*. Hence the opposition which the introduction of the new semi-metals, cobalt, nickel, and manganese still meets with among Mineralogists of the antient stamp.

However at last, happily for science a few distinguished characters appeared, who, rejecting all hypothetical delusions, determined, not only to submit to no other guide but actual experiment, and its necessary consequences, but also to follow it wherever it led them. Of this truly philosophic band, Mr. *Margraaf* of *Berlin* led the van, followed by a few others, particularly in *Sweden*. Discoveries now multiplied apace in the hands of a *Brandt, Swab, Cronsted, Gabn*, and particularly Mr. *Scheele*, until at last Mr. *Bergman* of *Upsal*, by the solidity of his judgment, the ingenuity and accuracy of his methods, and the multiplicity of his experiments, brought Mineralogy to that degree of perfection at which we at present behold it.

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CORRECTIONS.

- P. Line
 12. 14. *Dele* they
 16. 10. *Dele* and
 34. for Species III. *read* Species IV. and correct the numerals of the other Species, as far as p. 46, where for Species XI. *read* Species XII.
 36. 1. *read* if Iron be precipitated from the sparry acid by lime water, the precipitate will be white, &c.
 36. 21. *read* commonly cubic, sometimes octagonal, or polygonal.
 51. 6. *for* proceeds the shiftus, *read* proceeds from the shiftus.
 75. 21. *for* 60 of, *read* 60 per cent of.
 118. 6. *for* parallelipedal, *read* parallelopipedal.
 120. 18. *for* parallelipeds, *read* parallelopipeds.
 147. 4. *for* rnelian, *read* carnelian.
 153. 14. *for* Metallic stone, *read* Metallic rock
 200. 9. *for* selentino, *read* selenite.
 384. 20. *for* 1000, *read* 10000.

ADDITIONS.

114. 3. Mr. Greville possesses an agate, speckled with yellow pyrites, which is called an *Avanturine*.
 139. 17. Mr. Dolomieu has lately discovered at *Stromboli*, another sort of pumice, which seems to be a ferruginous granite altered by fire.

E L E M E N T S

O F

M I N E R A L O G Y.

MINERALS in their strictest signification denote only such substances as are found in mines, such as Metals, Semi-metals, Sulphur and Salts; but in a more extensive sense, they denote all fossils that do not belong either to the vegetable or animal kingdoms, and consequently Stones and Earths, all of which are comprehended under the Denomination of the *Mineral kingdom*.

The mineral kingdom is therefore usually divided into four parts or classes, viz. I. *Earths, and Stones*. II. *Salts*. III. *Inflammable Substances*. IV. *Metallick Substances*: which naturally point out a similar fourfold division of this treatise.

B

PART

P A R T I.

Of EARTHS and STONES.

By *Earths* are commonly understood tasteless, inodorous, dry, brittle, unflammable substances, whose specific gravity does not exceed 4,5. which are incapable of being metalized, are scarcely soluble in water, and give no tinge to Borax when melted with it. However Quicklime is usually called an *Earth*, though it has a pungent taste and is very perceptibly soluble in water, so also are limestone and gypsum, though they both contain a purely saline principle, and therefore in my opinion they and some other such substances may be classed both among Salts and among Earths. Nay it appears that all Earths are soluble in some very large proportion of water. Hence I think with *Mr. Bergman*, that in the strictest sense the term *Earth*, should, exclusively of any other denomination, be appropriated to substances of the above description, that require above one thousand times their weight of boiling water to dissolve them, and that those which are soluble in between four hundred and one thousand times their weight of water may be called either salts as technical, or Earths as common language requires.

Stones

Stones differ from *Earths* only in hardness and its consequences, and therefore are included under the same generical name. Yet diamond is also called a Stone, though it probably contains little Earth of any kind.

CHAP. I.

Of Simple Earths, their number and Characters.

By *simple Earths*, I mean those which possessing permanently distinct characters, are incapable of being further analyzed or changed into any other, by any means hitherto known. Of these, we know only five. The *Calcareous*, the *Ponderous*, the *Magnesian* or *Muriatic*, the *Argillaceous*, and the *Siliceous*. All Stones and Earths hitherto examined, are found to consist of these either singly, or mixed, or chymically united with each other, in various proportions, together with saline, inflammable and metallic substances; for in the Earth they are seldom or ever found perfectly pure.

Of the Characters of Calcareous Earth.

1st. When perfectly pure and free from all combination, it constitutes *lime*; its specific gravity is about 2,3. it has a hot burning taste, acts powerfully on animal substances,

4 *Elements of Mineralogy.*

and when in lumps, heats with a moderate quantity of water.

2^d In the temperature of 60° it requires about six hundred and eighty times its weight of water to dissolve it; its taste is then pungent, urinous, yet sweetish.

3^d It is combinable with all acids, and in particular easily soluble in the nitrous or marine, but difficultly crystalizes with them, as it forms deliquescent salts, and is in great measure precipitable from them by the vitriolic, to which it preferably unites, forming gypsum or selenite, which is wholly precipitable from them by the affusion of highly rectified spirits of wine, or moderate evaporation, nitrous selenite easily parts with its acid, when calcined in open vessels and a red heat; but marine selenite scarcely. Both selenites have a bitter taste.

4th. When in vessels on which it cannot act, it is infusible *per se* (that is singly;) in a heat that would melt iron: yet *Mr. Parker's* glass seems to have induced a slight beginning of fusion in lime, even when it stood on charcoal, but if mixed with argillaceous, magnesian or siliceous Earths, it will melt in a more moderate heat, and particularly if mixed with two or more of those Earths. And
hence

hence it is fusible in earthen vessels, even of porcelain; it is scarcely affected by fixed alkalis, but easily melted and without effervescence by borax or microcosmic salt, or calces of lead.

Ponderous Earth.

1st. This may more conveniently be called *Barytes*, when pure it is also in the state of lime, which it perfectly resembles in taste, but it requires nine hundred times its weight of water to dissolve it in the temperature of 60°

2^d. It is combinable with acids, but with the nitrous and marine, it forms salts that do not deliquesce, and with the vitriolic, a salt much more difficultly soluble than gypsum; it decomposes tartar vitrolate, an effect which no other Earth can operate.

3^d. It is precipitable from the nitrous and marine acids by the Prussian Alkali, a property which also distinguishes it from all other Earths.

4th. In the dry way it acts and is acted upon nearly as calcareous Earth, but it is something more fusible by the mineral alkali. Its specific gravity exceeds 4,000.

Magnesia or Muriatic Earth

1st. Its specific gravity when perfectly pure is about 2,33.

2^d. It requires about seven thousand six hundred and ninety-two times its weight of water to dissolve it in the common temperature of the air.

3^d. It is combinable with acids, and though the vitriolic easily separates it from the nitrous and marine, yet it does not precipitate it, as it does calcareous Earth and barytes, but forms Epsom salt which is bitter and soluble in its own weight of water; whereas with the former Earths it forms insipid and very difficultly soluble compounds.

4th. Exposed to the strongest heat, it will neither burn to lime, nor melt *per se*, but loses much of its weight, partly by evaporation, and partly by the loss of a certain proportion of water, which it naturally retains. Neither will it vitrify in company with any other simple Earth, except the calcareous, of which, according to *Mr. Achard* 100^{gr}. will promote the fusion of from twenty-five to fifty of magnesia, it will also melt with argillaceous and siliceous Earths together, and much more readily if calcareous Earth be added to them. Like
lime

Argillaceous Earth.

7

lime it is brought into fusion by borax or microcosmic salt, but is scarcely affected by fixed alkalis, or calces of lead.

Argillaceous Earth or Earth of Alum.

1st This may more conveniently be called *Argill*, its specific gravity when pure does not exceed 2,000.

2^d It is exceedingly diffusible, but scarcely more soluble in water than pure magnesia.

3^d It is combinable with acids, and when combined with the nitrous or marine, like magnesia it is separable, but scarcely precipitable by the vitriolic acid* with which it forms Alum, which always contains an excess of acid and has an astringent taste; when combined with any of these acids, it is not precipitable by the acid of sugar, which distinguishes it from the foregoing Earths, all of which (except the ponderous united to the vitriolic acid) are precipitable from the vitriolic, nitrous and marine acids, by that of sugar, though the precipitation is not always apparent before the liquors are evaporated, nor at all, if there be an excess of the mineral acids.

* For if concentrated oil of vitriol be dropped into a very saturate solution of nitrous or marine Alum, a greyish precipitate will immediately appear.

4th. The strongest heat barely hardens it, but does not give it the qualities of lime, nor melt it, while single, or accompanied only with magnesia or siliceous Earth; but mixed with calcareous, it runs into fusion very readily, and hence *Mr. Gerhard* has found it fusible in a crucible of chalk, but not in one of clay; fixed alkalis do not promote its fusion, but borax and microcosmic salt dissolve it, the first with scarce any, and the latter with a more notable effervescence. Calces of lead affect it something less than they do calcareous Earths.

Siliceous Earth.

1st. This is by some called crystalline, quartz, or vitrifiable Earth, as it is that of which glass is usually formed; its specific gravity is 2,65, and consequently it is the heaviest of all the simple Earths, except the barytes.

2^d. It seems less soluble in water than any other, yet in the common temperature of the atmosphere ten thousand parts of water may contain one of this Earth; and in very high degrees of heat, much exceeding that at which water usually boils, it seems soluble in a much greater proportion,

3^d. It

3^d It combines with no acid hitherto known, except the sparry, which either in a liquid or aerial state, but particularly in the latter, is capable of holding much of it in solution, which it deposits either on cooling or coming in contact with water, or substances with which it has a greater affinity. But caustic fixed alkalis may even in the liquid way take up from $\frac{1}{10}$ to $\frac{1}{6}$ of their weight of this Earth according as it is more or less subtilly divided, and hence it is not improbable that even lime-water has some action on it.

4th. It is infusible *per se* in the strongest heat, neither does argillaceous or magnesian Earths promote its fusion, the effect of calcareous Earth is somewhat more doubtful, for Mr. Achard* and Mr. Scheffer,† assert that these Earths do not melt together, but Mr. Darcet,‡ and also Mr. Bergman,§ and Mr. Swab, || say that two parts lime melt one of quartz; at least there is no doubt but this may be effected in vessels of clay, for an admixture of this will make the other two Earths immediately yield. Fixed alkalis, particularly the mineral, readily melt double their weight of this Earth with effervescence, borax affects it more difficultly, and with scarce any effervescence, and microcosmic salt has hardly any action

* Mem. Berlin, 1780, p. 32. † Foreles. § 175, b.
‡ 22 Roz. p. 27. § Scheff. Foreles. § 175, b. 2 Anmerk.
|| 2 Memoires d'Upsal, p. 443.

on it; calces of lead act on it more powerfully than on argill, but less than on calcareous Earth, and melt from $\frac{1}{3}$ to $\frac{1}{2}$ their weight of it.

The calcareous, ponderous, magnesian and argillaceous Earths being combinable with all acids, may be called *absorbent* Earths, in contradistinction to the siliceous, which unites only to the sparry acid.

Besides the general characters of these Earths, here given, *Mr. Bergman* has observed and noted their different powers of absorbing and retaining water; after moistening equal weights of siliceous sand, chalk, magnesia, and Earth of alum, with as much water as they could take up without dropping, he found that the sand took $\frac{1}{4}$ of its weight, chalk $\frac{1}{2}$, magnesia $1\frac{1}{20}$, and Earth of alum $2\frac{1}{2}$, and when all these moistened Earths were exposed to the same heat, the sand lost its water first, then the chalk, then the magnesia, but the argill, not until red-hot.

Again one of the characters of argillaceous Earth is the extreme subtilty and fineness of its integrant parts, which render it smooth to the touch, and slowly separable from water when diffused through it, also a certain viscosity

dity and ductility which proceed from its power of retaining water, and of these properties magnesia also participates though in a lesser degree. Siliceous Earths on the contrary are characterised by roughness, hardness, sharpness to the touch, and a total want of flexibility and adherence to each other, when minutely divided, and a ready separation from water; of these properties calcareous and ponderous Earths participate, though in a lesser degree.

C H A P II.

Of the Affinities of Earths to each other.

The above mentioned Earths are never found in nature perfectly pure, but always combined or mixed either with a saline or inflammable principle, or with each other, or with some metallic principle, particularly iron, besides water; when mixed with any notable proportion of the inflammable or metallic principles, or even of the saline, so as to exhibit the characters of such principles, they shall be treated of under those particular heads; I shall here consider only such compounds as retain the general characters of Earths, and as in conformity with *Mr. Cronsted*, I intend deducing the various *species* of Earths from their union either with saline principles or with each other, it will be necessary to indicate the affinities on which such unions are founded;

founded; the affinities of Earths to acids are generally known, but those of Earths to each other and to calces of iron have nowhere been treated of; and therefore require some developement.—The efforts of art can scarcely exhibit in the *humid* way, the affinities of Earths to each other, if this could be effected, we should probably find the same election and preference take place among them as among Earths and acids, we are therefore obliged to have recourse to the *dry* way, which is much more imperfect: for as they are all reduced by fire to a state of liquidity, they differ but little in specific gravity, and can difficultly be examined while in fusion, when cold they are all found so mixed that it is not possible to judge of their affinities by the way of preference and exclusion; but if we judge of these affinities as we do of that of water to salts, by the greater or the lesser quantity which one of them considered as a menstruum, can take up of another or what proportion of the one determines the fusion of another, we may in that manner form a tolerably accurate idea of their different attractive powers.

Among the simple Earths, the calcareous alone,* can be looked upon as the menstruum

* Perhaps the ponderous may also have this property, but it being scarce, no experiments have yet been made with a view to determine this point.

um of other Earths, for according to the important discovery of *Mr. D'Arcet*, they are all rendered fusible by a proper proportion of this Earth, though infusible of themselves. A discovery which throws the greatest light, not only on mineralogy, but also on metallurgy and the arts of vitrification and pottery; now calcareous Earth requires for its fusion half its weight of magnesia, and only $\frac{1}{4}$ of its weight of argillaceous Earth, according to the experiments of *Mr. Achard*.† He did not indeed observe that it had any effect on siliceous Earth, but this appears to be owing to his having used too small a proportion of the calcareous, for *Mr. Gerhard*‡ having exposed siliceous Earth to a violent heat in a crucible of chalk, found it vitrified in the edges where it touched the chalk, but we may infer that this Earth is less acted upon and more difficultly than the foregoing; even in the liquid way, calcareous Earth in some cases manifests the same affinities, thus if Earth of alum perfectly pure be added to lime water, it will precipitate the lime as *Mr. Scheele* has shewn in the *Memoirs of Stockholm*, for 1776, and the precipitate is soluble in the marine acid, which shews that the precipitation does not arise from any remains of the vitriolic acid in the Earth of

† *Mem. Berlin*, 1780. ‡ 2 *Gesch. Mineral Reich.*

alum,

alum, as gypsum in that case would be formed, which is insoluble in the marine acid, but pure magnesia, that is, free from aerial acid, does not precipitate lime water.

X argillaceous
 Siliceous Earth seems also to have some affinity to the argillaceous, for although it cannot be brought into fusion by the argillaceous, yet when melted by fixed alkalis it acts on the argillaceous Earth of the crucibles and dissolves it; now fixed alkalis singly, cannot melt argillaceous Earth; to say nothing of the hardening power of argill and siliceous Earths, when mixed together and heated.

Iron in a more or less dephlogisticated state, being found in some proportion mixed or united with almost all sorts of Earths and Stones, deserves also to have its affinities to them mentioned, it is much more fusible than any of them, and may therefore be considered as a menstruum. *Mr. Achard* has found that an hundred parts of calx of iron are capable of melting four hundred of calcareous, fifty of argillaceous, thirty-three of siliceous and twenty-five of magnesian Earths, it acts still more powerfully on lesser proportions of these Earths.

Hence,

Hence the affinities of these Earths, and calces of iron to each other, seem to me to stand in the following order.

<i>Lime,</i>	<i>Magnesia,</i>	<i>Argill,</i>	<i>Silex,</i>	<i>Calx of Iron.</i>
Calx of Iron,	Lime,	Calx of Iron,	Calx of Iron,	Lime,
Argill,	Calx of Iron,	Lime,	Lime,	Argill,
Magnesia,		Silex,	Argill,	Silex,
Silex,				Magnesia.

When substances are dissolved and at liberty, their affinities whether in the moist or dry way, are exactly the same, they being equally divided; and the only difference is, that in one case, they are dissolved by fire, in the other by a liquid. We may also observe, 1st, that the less calces of iron are dephlogisticated, the greater is their power of attracting Earths as *Mr. Rinman* has discovered, and when dephlogisticated to a certain degree, they lose this power, their colour according to the degree of their dephlogistication is as follows, whitish, pale yellow, yellow, red, brown, green, and blue. 2dly. That when once lime or calces of iron have acted as menstrua upon any Earth, a compound menstruum arises, which acts much more powerfully on other Earths; thus, though one hundred parts of lime can dissolve or liquify very little of silex, yet when these hundred parts of lime have taken up fifty of magnesia, they are enabled to dissolve one hundred of silex, and
this

this last compound forms a menstruum still more compound, which is able to dissolve still more of magnesia, for equal parts lime, magnesia, and filex form a perfect glass; and hence equal parts of any three of the simple Earths will vitrify in a sufficient heat, so that calcareous Earth be one of the three; nay one part lime and one of argill will melt 2 or $2\frac{1}{2}$ of filex, and other mixtures are more or less fusible as they approach to this proportion.

The principal marks of Chymical Union are the following.

1st. *A specific gravity exceeding that of the heaviest of the ingredients of the compound, or even greater than the intermediate.* But it does not follow that, where such density is wanting, a chymical union does not exist, for the peculiar structure of the compound which does not admit water into its vacuities may hinder this property from being observed, so may also a certain quantity of water which enters into the composition, and cannot always be made sensible.

2^d. *Transparency*, when this property is found in combinations of Earths with each other, or with saline substances, it indicates a chymical union; but such an union is also
consistent

consistent with opacity, as this may arise from a mere mechanical arrangement of the parts, or the interposition of some that are not chymically combined, too great thickness, &c.

3^d. *Crystallization*. This proves that the parts of the chrytallized substances have been at some period very minutely divided; and in general that they have been chymically combined with the menstruum, in which they chrytallized; though I agree with *Mr. Bergman* that a chymical union with such a menstruum is not always requisite; but it does not prove that they were chymically combined with any other substance which chrytallizes with them, except some other mark of such union appears, and particularly a density greater than could be expected from the proportion and density of the component parts.

4th. *A more difficult Solubility* in their common menstrooms, and of course a still greater difficulty of solution in menstrooms, that act only on one of the component parts. Of this there are numberless instances, yet there is one exception, viz. where one of the component parts is resolvable by the action of the menstruum into an elastic fluid, which by its eruption so powerfully agitates and
C divides

divides the compound, as to render it more soluble. Thus lime-stone, and mild magnesia, are more easily dissolved than either lime or calcined magnesia. On the other hand, some metallic calces are more easily dissolved in certain acids, than they are when furnished with phlogiston, though this also be resolvable into an elastic fluid; but this I have elsewhere explained. The calces of iron are so much the more difficultly dissolved, as they are more dephlogisticated; hence the whitish calx is most difficultly dissolved; and next to that the yellowish and red; but the brown, green, and blue, most easily; and hence, stones which contain dephlogisticated calces of iron and unareated Earths, are most difficultly dissolved, though the calces are not so strongly attracted by the Earths, nor consequently the stones so hard, as those that contain iron in a more phlogisticated state. This accounts for the difficult solubility of talc, mica, &c.

C H A P. III.

Of the Systematical Arrangement of Earths and Stones.

All Earths may be divided into simple and compound. Simple are the five unalterable kinds already described, which constitute five sorts or *genera*, under which all terrene compounds may be ranged.

By

By *Compound Earths*, I understand those that are combined or mixed in a *notable* proportion, either with each other, or with a saline, inflammable, or metallic principle, yet not in sufficient proportion to require them to be arranged under such foreign principles. Such compounds being permanent, and being the foundation of a peculiar denomination, I call *species*, and simple species, in order to distinguish them from super compounds, which will presently be mentioned. Thus *gypsum* is a compound Earth, consisting of calcareous Earth, and a saline principle, not accidentally, but permanently mixed with it. So also *tourmaline* is a compound Earth, consisting of the argillaceous, siliceous, and calcareous, and iron, in proportions determined within certain limits, and forms a simple species. I said a *notable* proportion, because it is difficult to assign this proportion with precision; for it relates to denominations of substances, and these are founded on the necessity of distinction, arising sometimes from the usefulness of substances to mankind, and sometimes from caprice. Thus, a compound Earth, which should consist of calcareous Earth, and only two per cent. of gold or silver, would be denominated an *ore*, whereas, if it contained only two per cent. of iron, or of another Earth, it would still retain the name of, and be reckoned among, calcareous Earths. However, in general we

may say, that any proportion which produces peculiar effects, or is the foundation of some particular use, is *notable*. When iron is found in any Earth or Stone, in the proportion of 14 or 15 per cent. it commonly renders it magnetic, either before or after torrefaction, according to its state of phlogification; and if it be found in the proportion of 30 per cent. or more, it gives the compound the denomination of an *ore*. To stones that contain a greater quantity of iron than is essential to them in the purest state, I add the denomination *martial*, or *ferruginous*.

When simple Earths, belonging to different *genera*, are mixed or combined with each other, I generally place them under that *genus* of which the compound contains the largest proportion, yet not always, for if the compound possesses the peculiar characters of the component part, which is in a smaller proportion; or if it attracts the attention, and is subservient to the uses of mankind, merely on account of the less copious ingredient, I range it under the *genus* of that ingredient. Thus, though common clay contains much more of siliceous than of mere argillaceous Earth, yet, as it possesses smoothness, viscosity, and softness, in a high degree, it would appear ridiculous to place it under the siliceous genus, whose characters are the very reverse. For the same reason, I place the
precious

precious stones under the siliceous genus, though the argillaceous be, in point of proportion, predominant in their composition.

By *super-compound* Earths or Stones, I mean aggregates of *visibly different simple species*, in a notable proportion, whether these species belong to the same, or to different *genera*. Thus I would call a compound of gypsum and fluor spar a super-compound, though both belong to the calcareous genus; and *a fortiori* granites and porphyries, which form aggregates of simple species belonging to different *genera*. Super-compounds, therefore, form *compound species*, which may be ranged under that genus which is found in them in greater proportion. In general they may be known by the eye, at least when aided by a lens.

In strictness, Earths of different *genera*, each of which contain the aerial acid, should, when mixed with each other, constitute a compound species, yet, as this acid is easily expelled, and causes no great difference in the properties of the compound, and as in fact absorbent Earths, when combined with no other saline principle, are seldom without it, I shall rank those compounds among the simple species, and so I shall quartz and flint, though seldom absolutely pure,

C H A P. IV.

Calcareous Genus.

SPECIES I.

Calcareous Earth, uncombined with any Acid.

This stone is of a grey colour, moderately hard, or rather soft, found near Bath; it is mixed with calcareous Earth combined with fixed air; and hence it effervesces with acids, but at the same time it is soluble in water, to which it communicates the taste of lime; and if this solution be mixed with sulphur, it dissolves it, and forms a calcareous liver of sulphur, with the assistance of heat; whence it is plain that part of the calcareous earth is in an uncombined state. See *Falconer* on Bath Waters, vol. i. p. 156 and 257. When exposed to the air for some time, it hardens, by attracting a sufficiency of the aerial acid. I have observed several lime-stones to have the same property of hardening some time after they have been dug. *Mr. Monnet* also found this Earth in a loose, dry, powdery form, of a yellowish colour, in the mountains of Auvergne, and suspected it to be of volcanic origin. *Mineralogie*, p. 515.

SPECIES

SPECIES II.

Combined with the Aerial Acid.

This species comprehends a great variety of external appearances, the most remarkable of which are transparency and opacity, hence I shall divide it into two series, the transparent and opake; all effervesce with acids; none give fire with steel; the chrystalized decrepitate when heated.

SERIES I,

Transparent Spars.

These are of a lamellar texture, and mostly break or split into rhomboidal laminæ; and this structure is generally called spathose, or sparry. They are found crystallized in various forms, rhomboidal, hexangular, triangular, polyangular; but the most common is the rhomboidal, of which sort is the Iceland crystal, which possesses a double refracting power.

Their specific gravity is generally about 2,700, when pure from metallic particles; and they generally contain from 34 to 36 per cent. of the aerial acid, from 53 to 55 of mere Earth, and the remainder water.

C 4

These

These spars when pure are always colourless, but sometimes they are found green, brown, reddish, yellowish, and even black, from a mixture of metallic particles.

De la Hire and *Huygens*, denote rhomboidal spar under the name of talc.

SERIES II.

Opake.

Under this series I range a variety of stones of the same species, but which are known under various denominations arising from external properties, or the apparent mode of their origination; such as opake-spars, stalactites, tophuses, incrustations, petrifications, agaric-mineral, chalk, limestone, marble.

Opake Spars.

These are chrystalized under the same regular forms as the transparent spars, and sometimes appear in a globular form; their texture is also lamellar, they are of different colours like the foregoing; the red frequently receive that tinge from manganese,
16 Roz. 15.

Stalactites,

Stalactites, Sinter Calcareum, Stiria.

These are found suspended from vaults, being formed by the oozing of water charged with calcareous particles, and gradually evaporating, leaving those particles behind; this deposition can scarce be called a chrysalization, as the calcareous particles do not appear to have been dissolved, nor even very minutely divided, though this sometimes happens, whereas transparent spars appear to have been formed from a solution in water, by means of the aerial acid. Stalactites are of a lamellar or granular texture, and either in a branchy form, or in that of perforated cones, or globular, and then called *stalagmites*, *oolithes*, *pisolites*, &c. Most of these stones contain a slight mixture of argill and calx of iron. And hence are of a grey, brown, yellow, or blackish colour.

Tophi, Duckstein of the Germans, Pori.

These differ from the former, not only in shape, but principally in this, that they have been formed by a gradual deposition of Earths, chiefly of the calcareous kind, barely diffused through water, within the water itself and not in air. Hence they are of a soft and porous texture, and of the same colour

colour as the foregoing, the purest sorts alone are placed here.

Calcareous Incrustations.

These are generally found on branches or roots of trees, and sometimes on stones of different kinds, the most remarkable of these incrustations is that found on the roots of pines, called *Osteocolla*, which Mr. Margraaf found to consist chiefly of calcareous Earth, mixed with a small proportion of siliceous, and volatile alkali, together with some vegetable parts.

Calcareous Petrifications.

These consist of calcareous stones, in the form of animal or vegetable substances, the former are called *Zoophytes*, the latter *Phyolithes*.

The most remarkable of the former are, 1st, Those of the *Coral* class, of a ramified and tubular form as coral, madrepores, millepores, astroites. 2d, Those of the class of sea worms, belemnites, which are of a conic or cylindrical form. *Asterie* and *Entrochi*, which have a starry appearance. 3d, Those of the testaceous class, as *nautilites*, *ammonites*, *echini*, &c.

Agaric

Agaric Mineral, Guhr.

This fanciful name denotes only a loose calcareous Earth found in the clefts or cavities of rocks, mostly white, but sometimes red or yellow, from a mixture of clay or ochre.

Chalk, Craie, Craie de Champagne, blanc d'Espagne of the French.

This substance is too well known to need any description, the purest is *white*, yet it contains a little siliceous Earth, and about two per cent. of argill. Mr. *Rinman's* History of Iron, § 201, mentions a blue chalk found in the neighbourhood of *Upsal*, which contains iron. Mr. *Beaumé* says that the purest calcareous Earths he has met with contain some small proportion of iron, which deposits from solutions long made. 1 *Beaumé* 255. however I have frequently used chalk, in whose solution neither galls nor Prussian alkali could discover any. Dry chalk contains more aerial acid than any other of the calcareous class; generally about forty per cent. its specific gravity is from 2,4, to 2,65.

Limestones,

Marbles.

Opake stones of any sort, something harder than limestones, more compact, of a closer grain and susceptible of a good polish, have been called *Marble* by statuary, but this name is now appropriated to stones of the above description, of the calcareous genus only. The specific gravity of Marbles is from 2,7 to 2,8, their texture like that of limestones is either lamellar or granular and their colours various, not only in different masses, but in one and the same piece; these last will be mentioned among the compound species: when the different species are in large distinct masses they are called *Breccias*, Marbles of three colours, grey, yellow, and black; which abound in petrifications, are called *luma-chellis*; those of four colours, white, grey, yellow and red, are called *Brocatello's*. I shall here only mention the purer sorts that contain the least mixture of foreign genera.

White Marble, particularly that of *Carrara*, is the purest with which we are acquainted; it is of a granular texture and sparkling in its fracture like sugar; its specific gravity is 2,7175, of this sort is the *Pietra Elastica* of *Rome*. *Ferber, Italy*, 130. Other white marbles are not so pure, many are of a lamellar texture.

Black.

Black. This colour is commonly owing to a slight mixture of Iron. Mr. *Bayen* found one specimen of it to contain five per cent. of iron, yet the lime made of it was at first white, but in time acquired an ochry, or reddish yellow colour, 11 *Roz.* 496.

Mr. *Bergman* remarks, that all calcareous stones which grow black or brown by calcination, may be suspected to contain manganese, in that case the lime they form is excellent as a cement. 2 *Bergman*, 229. And according to *Rinman* (*History of Iron*, § 189,) white calcareous stones, that grow black by calcination, contain about ten per cent. of iron.

Grey. This sort of marble contains less iron, only one or two per cent. according to Mr. *Bayen*.

Blue and Green marbles derive their colour from a mixture of shorl, according to Mr. *Rinman*, *Historia ferri.* § 201. 206.

SPECIES III.

Combined with the Vitriolic Acid.

Gypsum, Selenite, Plaster of Paris.

This species is of different colours, mostly white or grey, of a lamellar, granular, or fibrous

fibrous texture, of a moderate hardness, not so great as to give fire with steel; sometimes opaque, sometimes pellucid, sometimes regularly chrysalized, and sometimes amorphous.

Its specific gravity is 2,32 generally, sometimes only 1,87.

It is soluble in about five hundred times its weight of water, at the temperature of sixty. It does not effervesce with acids, and is difficultly soluble in any, particularly in the marine.

When heated a little below ignition, it undergoes a motion similar to that of ebullition, from the dissipation of its aqueous part, and falls into powder; if taken up when this motion ceases, and sprinkled over with water, it soon concretes and hardens, by reason of its sudden chrysalization.

If calcined with $\frac{1}{4}$ of its weight of charcoal, it yields a liver of sulphur, and the Earth thus separated, treated with black flux, frequently yields a little of Iron: it is fusible *per se* by the blow pipe. 2 *Bergman*, 469, or in a long continued porcelain heat, 22 *Roz.* 26, though Mr. *Gerhard* says this does not happen in crucibles of chalk, but only in those of clay. 2 *Gerb. Gesch.* 16.

It.

It contains about 30 per cent. vitriolic acid, 32 of mere Earth, and 38 of water; of which it parts with about 20 by calcination. The best method of decomposing it is to boil it, well pulverized, in a fixed alkaline lye.

The varieties of its external appearances may be presented under two series, the transparent and opaque.

SERIES I.

Transparent.

Lapis Specularis, Vitrum Ruthenicum, Glacies Mariæ, Stirium Pellucidum, Gypsum Spathosum Diaphanum.

This is either colourless, or yellowish, green, or reddish; which last colour is from iron, as Mr. Morveau has, by means of vinegar, completely separated it. Its form is either amorphous, or regular, generally cubic; its texture lamellar, scaly, or fibrous.

SERIES II.

Opaque.

The colour of this is either white, grey, yellowish, greenish, or black; its texture
D scaly,

lcaly, fibrous, or granular; its shape either regular as cubic, rhomboidal, or prismatic, consisting of three or five sides; or amorphous, of which sort is *alabaster*, whose texture is granular, with shining particles, and its specific gravity 1,87.

SPECIES III.

Combined with the Sparry Acid.

*Fluor, Spathum fusibile, Pétunse of Margraaf,
2 Theil. p. 45, Blue John.*

Its colours are various, being either white, yellow, blue, green, reddish, purple, brown, or colourless; its texture sparry or shattery; its form either amorphous or regular; its hardness not so great as to give fire with steel; its specific gravity from 3,14 to 3,18; if greater it proceeds from a large proportion of metallic or other foreign particles.

It is insoluble in water, does not effervesce with acids, and is scarcely soluble in them without decomposition.

When heated it decrepitates and bursts, but does not yield lime, nor harden by the infusion of water, as gypsums do. The coloured fluors become phosphorescent when heated slowly.

slowly, below ignition, but lose this property when made red hot, and also on cooling. It melts *per se* in a strong heat, and violently attacks the crucibles, as it powerfully promotes the fusion of argillaceous Earths. It is also fusible with mineral alkali, borax or microcosmic salt, and without effervescence. It consists of the sparry acid, water, and calcareous Earth. According to *Mr. D'Arcet*, the acid is in the proportion of 16 per cent. 22 *Roz.* 24. and according to *Mr. Scheele*, 100 gr. of fluor contain about 57 of mere Earth, and consequently about 27 of water; but I believe it contains much less water, and much more acid, for a great deal of the acid pierces through the luting during distillation.

It is decomposed by distilling it with three times its weight of concentrated vitriolic acid, but to obtain the sparry acid pure, it should be distilled with its own weight of that concentrated acid pure and colourless, at first with a gentle, and towards the end with a strong heat, placing water in the receiver, in the proportion of 10 or 12 times the weight of the spar. The nitrous and marine acids decompose it if dilute, but not when these acids are concentrated.

Blue fluors derive their colour mostly from iron, but sometimes from cobalt. 2 *Berlin.*

Beschäft. 330 ; and in fact, iron, precipitated from the sparry acid by lime water, is white, with blue specks. Green fluors owe also their colour to iron. *Rinman*, § 206.

Most fluors contain a mixture of argillaceous and siliceous Earths, and some marine acid. The siliceous Earth, which sublimes in distilling these spars, arise, from the solution of that pre-contained in the spar, or from the corrosion of the glass vessels, as Messrs. *Mayer* and *Wiegleb* have shewn ; this acid possessing the singular property of dissolving siliceous Earths, and consequently glass.

The varieties of this species may be reduced to two, the transparent and opaque ; of which there are necessarily many intermediate shades.

SERIES I.

Transparent.

These are generally of a regular shape, cubic, rhomboidal, polygonal, and of different colours ; and hence called pseudo-emeralds, sapphires, topazes, amethysts, &c.—Some are amorphous.

SERIES II.

SERIES II.

Opake.

These are distinguished by the same colours; their texture also is generally the same, but it is said to be sometimes granular; their form is also regular, or amorphous, like the foregoing.

The phosphorescent property of fluors seems to arise not from the acid singly, otherwise all fluors would possess it, but from the acid, in contact with metallic particles, and consequently from the acid and phlogiston.

SPECIES IV.

Combined with the Tungsten Acid.

Tungsten, Lapis Ponderosus, Schwerere Zingraupen of the Germans.

When pure it is of a grey colour and lamellar texture, gives fire with steel, and is very weighty, its specific gravity being from 4.99 to 5.8.

It is insoluble in acids, except by peculiar management; when powdered and digested
D 3 with

with the nitrous or marine, it assumes a yellow colour, as Mr. *Woulfe* first observed, *Phil. Transf.* 1779, p. 26.

When heated it bursts, becomes reddish, melts very difficultly *per se*; nay, according to Mr. *Bergman*, it is infusible with the blow pipe, and not totally fusible even with the assistance of fixed alkali, but easily by borax, and without effervescence. It also easily melts with its own weight of fluor,

Its constituent parts were discovered by Mr. *Bergman* and Mr. *Scheele*, nearly at the same time, but first published by Mr. *Scheele* in the Swedish Memoirs for 1781. It appears to contain about $\frac{1}{2}$ its weight of calcareous Earth, and the remainder a peculiar acid of an earthy appearance, and iron.

This acid is separated from its earthy basis, by digesting the powdered stone in three times its weight of nitrous acid, and after pouring off this acid, and edulcorating the residuum, digesting it again in caustic volatile alkali, after some time the alkali is also poured off, and the residuum being edulcorated, is again digested in nitrous acid, and afterwards in volatile alkali: These successive digestions are continued until the greater part of the stone disappears, the nitrous acid constantly
taking

taking up the calcareous Earth, and the volatile alkali uniting to the tungsten acid; at last the tungsten acid is precipitated from the volatile alkali in the form of a white powder, by saturating the alkali with any other acid. This powder is soluble in 20 times its weight of boiling water, and then reddens litmus, has an acid taste, and with lime water produces a regenerated tungsten; its specific gravity is about 3,600.

SPECIES V.

Mild Calcareous Earth mixed with a notable Proportion of Magnesia.

I. VARIETY.

Compound Spar.

This stone is described by Mr. *Woulfe*. *Phil. Transf.* 1779, p. 29. It is there said to be either white and semitransparent, or of a pearl colour, or reddish, or of different shades of brown or yellow, of a peculiar gloss or brightness, like gold, brass, or copper; and to consist of flat, solid, and rhomboidal chrystals, and harder than calcareous spars. It effervesces with acids.

One hundred parts of it contain 60 of mild calcareous Earth, 35 of mild muriatic, and

5 of iron: the iron appears to be accidental, and its quantity greater or smaller, according to the colour of the stone.

II. VARIETY.

Creutzenwald Stone.

This stone is mentioned, but not described by Mr. Bayen. 13 Roz. 59. It is probably of a brown, or yellowish colour, and great weight; it contains by Mr. Bayen's account, 75 per cent. mild calcareous Earth, 12 mild magnesia, and 13 of iron. It is found near *Creutzenwald*, and there used as a flux for iron ores.

SPECIES VI.

Mild Calcareous Earth mixed with a notable Proportion of Clay.

I. VARIETY,

In a loose Form. Calcareous Marl.

Marl is well known from its use in agriculture. I distinguish two sorts of it, the calcareous and the argillaceous; it is of various colours, grey, yellow, red, brown, or bluish; these arise from a mixture either of iron or pyrites. The calcareous strongly effervesces

fervesces with acids; it is of different degrees of hardness, and readily bursts and falls into powder in water, or by exposure to the air. When the calcareous Earth is in large proportion it burns to lime, and even vitrifies in a stronger heat. The proportion of mild calcareous Earth is from 50 to 75 or 80 per cent. if greater it should rather be classed among chalks. Hence any Earth of this sort, that loses from 16 to 27 parts of its weight per cent. by solution in acids, may be deemed a calcareous marl, this being the weight of the volatilized fixed air which corresponds with the above proportion of calcareous Earth. Note also, that by *clay* I mean common clay, that is, a mixture of argill and siliceous Earth, in which this latter mostly predominates. See Dr. *Withering's* Dissertation. *Phil. Trans.* 1773, p. 161, and 3. *Edinb. Essays*, p. 4.

II. VARIETY.

In a Stony Form.

Travertino; Pietra Forte, Pietra Fongia of the Italians. Margodes.

The two first differ only in hardness; they are of a grey, blue, or yellow colour; the first loose and porous, the second harder; the third is a tufa, which, containing the seeds of mushrooms, produces them yearly, on being sprinkled

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sprinkled with water. *Ferber Italy*, 117, 159. They are often formed of volcanic ashes, indurated by water, and evidently contain some proportion of iron; the two first are used as lime stones. The *pietra colombina*, and *turchina*, are said to be of this sort.

Analogous to these is the *margodes*, a bluish grey stone, entirely resembling clay in its outward appearance, but so hard as to cut spars, or even zeolytes, but not to such a degree as to give fire with steel; dull in its fracture, its texture thick laminæ, and of a conchoidal form; its specific gravity 2,877; it effervesces with acids. I found it to contain 50 per cent. of calcareous Earth, about 32 of argill, 15 of silex, and 2 of iron.

Mr. *Bergman*, in his remarks on the mountains of *West Gothland*, *Memoirs of Stockholm*, 1768, mentions a sort of red marble found near *Roloock*, which contains so much clay that it hardens in fire, and even melts in a strong heat.

SPECIES VII.

Mild Calcareous Earth mixed with a notable Proportion of Ponderous Earth.

Barytical Limestone, or Marl.

This is said to be found both in a stony and loose form in *Derbyshire*; the former is said

said to be of a grey colour, and heavier than common lime-stones, but I have seen none of them.

SPECIES VIII.

Mild Calcareous Earth mixed with a notable Proportion of Siliceous Earth,

I. VARIETY.

Stellated Spar, Stern Spath, Stern Schoerl of the Germans.

This is opake, and of a radiated form, found in limestone by Mr. *Fichtel* on the *Carpathian Mountains*. It effervesces with acids, and according to Mr. *Bindheim*, 100 parts of it contain 66 mild calcareous Earth, 30 of siliceous, and 3 of iron. 3 *Schrift. Naturforsch. Freunde*, p. 454.

II. VARIETY.

Calcareous Grit, Calcareous Sand-stone, Calcarinus Arenarius, Pierre de Taille Calcaire, Moellon, Pierre de Liais. Monnet Mineralogie, p. 216;

Its colour is various, but mostly white, grey, brown, or of different shades of yellow: it effervesces with acids, and is more or less soluble in them, according to the proportion

portion of mild calcareous Earth, which also varies, from 50 to 70 or 80 per cent. when less, it should be reckoned among the siliceous sand-stones.

It frequently contains also a small proportion of argill, and a still smaller of iron. Its surface is generally rough; its texture mostly granular, but sometimes scaly: it does not strike fire with steel; it is sometimes used as a limestone; it hardens by exposure to the air; it is frequently sprinkled over with mica, but not in such proportion as to alter its genus or species. The sand-stone of *St. Helena*, which is very brittle, and burns to lime, is of this species.

SPECIES IX.

Mild Calcareous Earth mixed with Petrol in small Proportion.

Swine-stone, Pierre Puante, Stinksteine, Lapis Suillus, Orsten of the Swedes.

The colour of this stone is either white, grey, yellowish, brown, or black, with glittering particles; its texture granular, scaly, or lamellar; its form either round or prismatic, and polygon or amorphous; its grain compact and equable, or loose and open; its specific gravity consequently from two to three;

three; its hardness not so great as to give fire with steel.

It is soluble with effervescence in acids, but its most distinctive character is the offensive urinous smell it gives when rubbed: it loses this smell when heated sufficiently, and gives a slight flame when surrounded with burning coals, and at last burns to lime.

It affords little or no oil by distillation.

It frequently contains a little argillaceous Earth and Iron, and moulders by exposure to the air.

SPECIES X.

Mild Calcareous Earth mixed with a notable Proportion of Pyrites.

Pyritaceous Limestone, Pierre de St. Ambroix.

This stone was analysed by Baron Servieres, 21 Roz. 394. 22 Roz. 207. Its colour is iron grey, interspersed with shining particles. Its texture compact; its hardness such as scarcely to give fire with steel; its specific gravity 2,7034.

It is soluble in acids, and mostly with effervescence.

It

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It calcines in a strong heat, and makes nitre slightly detonate. If distilled, it affords a small portion of vitriolic acid, and some sulphur sublimes.

It consists of about 75 per cent. mild calcareous Earth, and 25 of pyrites, which contains 14 of argill, 7 of quartz and sulphur, and 4 of iron.

SPECIES XI.

Mixed with a notable Proportion of Iron.

I. VARIETY.

Mild Calcareous Earth mixed with Iron.

These stones are either yellowish white, or red: the former are of a scaly texture, and grow black when exposed to the air, very weighty, effervesce with acids, and contain about 25 per cent. of iron; the latter are of a coarse grain, slightly effervesce with acids, lose 30 per cent. by calcination, and contain 10 per cent. of iron. Some stalactites also contain from 20 to 27 per cent of iron. *Rinman Mem. Stock. 1754.* Other iron stones of this species, containing more iron, belong to the calcareous iron ores.

II. VARIETY.

II. VARIETY.

Tungsten intimately mixed with Iron.

Red or Flesh-coloured Tungsten.

It does not effervesce with acids, scarcely gives fire with steel; is of a coarse texture, easily pulverized: its specific gravity from 4,9 to 5,8; becomes magnetic after calcination; easily melted with its own weight of fluor; with great difficulty affords about 30 per cent. of iron. *Cronsted. Mem. Stock. 1751.* Hence it is never used as an iron ore.

Compound Species, in which the Calcareous Genus predominates.

SPECIES I.

Compounds of the different simple Species of the Calcareous Genus:

Here I place all the different compounds of mild calcareous Earth and gypsum, or fluor, or tungsten, &c. which may occur; also those of gypsum and fluor, gypsum and tungsten, or fluor and tungsten, &c. which may be placed as varieties of this compound species.

SPECIES II.

SPECIES II.

Compounds of Calcareous and Barytical Species.

I have seen yellowish stones of this species from *Derbyshire*, consisting of lumps of chalk interspersed with nodules of baroselenite: many more may occur, as compounds of gypsum and baroselenite, fluor and baroselenite, &c.

SPECIES III.

Compounds of the Calcareous and Muriatic Species.

Under this head I range all the compounds of mild calcareous Earth, or fluor, or gypsum, which contain steatites, serpentine, talc, amianthus or asbestos. Of this species the following varieties have been observed.

I. VARIETY.

White Marble interspersed with Spots of Steatites, or Soaprock Kolmord Marble. Cronsted. § 261.

This is of a scaly texture, and the steatites and soaprock either green or black.

II. VARIETY.

II. VARIETY.

1. *Pietra Talchina.*

This consists of white spar, with veins of talc.

2. *Verde Antico.*

A light green marble, with deep green, black, white, and purple spots; 100 parts of it contain, according to Mr. *Bayen*, 62 mild calcareous Earth, 30 of green talc, 1 of magnesia, and 1 of semiphlogisticated iron. 12 *Roz.* 56.

SPECIES IV.

Compounds of the Calcareous and Argillaceous Species.

I. VARIETY.

Mild Calcareous Earth and Argillaceous Shistus.

1. *Green. Campan from the Pyrenees.*

This is a marble of a green colour, and slightly magnetic. According to Mr. *Bayen*, 100 parts of it contain 65 of mild calcareous Earth, 32 of argillaceous, and 3 of semiphlogisticated iron, 11 *Roz.* 499. Since this

E

stone

stone is something magnetic, it is plain that the shiftus must contain at least 10 parts iron; and also, that this iron is not much dephlogisticated. Hence also, the colour is green, which colour, or blue, is always, when it proceeds from iron, a sign that the iron is not much dephlogisticated; on the contrary, a red or yellow colour from iron, denotes it to be in a dephlogisticated state:

2. *Red Campan.*

A red marble, not magnetic; 100 parts of it contain 82 of mild calcareous Earth, 11 of argillaceous shiftus, and 7 of dephlogisticated iron. 11 *Roz.* 501.

3. *Yellow figured Marble from Florence.*

Mr. *Bayen* found 100 parts of it to contain 75 of mild calcareous Earth, 13 or 14 of shiftus, and 4 or 5 of dephlogisticated iron.

4. *Griotte.*

A red marble from *Autun*; contains 67 of mild calcareous Earth, 26 of reddish shiftus, 2 of iron, and 1 of magnesia, per cent. according to Mr. *Bayen*.

5. *Amandola.*

5. *Amandola.*

A green honeycomb-like looking marble, containing white spots: 100 parts of it contain 76 of mild calcareous Earth, 20 of shistus, 2 of semiphlogisticated iron; the cellular appearance proceeds the shistus. 12 Roz. 56.

6. *Cipolin from Rome.*

A green marble, with white zones. It gives fire with steel, though difficultly; 100 parts of it contain 67,8 of mild calcareous Earth, 25 of quartz, 8 of shistus, 0,2 of iron, besides the iron contained in the shistus. 22 Roz. 52.

II. VARIETY.

*Calcareous Earth and Mica.*1. *Cipolin from Autun.*

A green marble, consisting of 83 parts mild calcareous Earth, 12 of green mica, and 1 of iron. 12 Roz. 55.

2. *Micaceous Limestone.*

This is of a glittering appearance, of various degrees of hardness, and effervesces
E 2 with

with acids; the proportion of mica is various. The *macigno* of the Italians is of this species. *Ferber*, 116. The yellow sort is called *pietra bigia*, the blue *pietra colombina*, or *turchina*.

SPECIES V.

Compounds of the Calcareous and Siliceous Species.

I. VARIETY. *With Quartz.*1. *Calcareous Quartz and Puddingstone.*

This consists of lumps of quartz, and sometimes felt spar, in a calcareous cement.

2. *Limestone with Veins of Quartz, Saxum Sahlbergense.*

Also several marbles in *Sweden* and *Siberia*, that strike fire with steel.

II. VARIETY. *With Lava.*1. *Calcareous Volcanic Puddingstone, Cierchina.*

In this, lumps of spar and lava are found in a calcareous cement. *Ferber Italy*, 115.

2. *Marble mixed with Veins of black or green Lava. Ferber Italy*, 67.

SPECIES VI.

SPECIES VI.

Compounds of Calcareous Earths with Species of two or more Genera.

I. VARIETY.

Calcareous Porphyry.

This consists of quartz, felt spar, and mica, in separate grains, united by a calcareous cement.

II. VARIETY.

Limestone interspersed with Shoerl and Mica.

C H A P. IV.

Barytic Genus.

SPECIES I.

Ponderous Earth combined with the Aerial Acid, aerated Baroselenite.

Dr. *Withering* presented me with a very pure specimen of this species from *Alston Moor*, in *Cumberland*. It much resembles alum, but its texture is striated: its specific gravity is 4.331, though when this compound is artificial its specific gravity is only 3.773, according to Mr. *Bergman*; evidently because it contains much water,

for 100 parts of it contain 65 of pure Earth, 28 of water, and 7 of the aerial acid ; whereas 100 parts of the native contain about 20 of aerial acid and 78 of Earth, a little of the vitriolic baroselenite, and no water. It effervesces with acids.

The artificial, when calcined, burns to lime, which has the properties of pure baroselenite already described ; but the natural will not burn to lime, for it will not part with its fixed air, but rather melts, as Dr. *Withering* has discovered. He also found that caustic alkalis precipitate this Earth from the nitrous and marine acids, which happens, as I think, from their taking up the excess of acid requisite to keep it in solution.

SPECIES II.

Combined with the vitriolic Acid.

Baroselenite, Marmor Metallicum, Cronst. 182, Lapis Bononiensis, Selenitic Spar, Gypsum Spathosum, Spathum Fusibile, Margraf 2, Theile. p. 44, Weigel Observ. Mineral. p. 65 and 66. Cawk, Petunse of some, Ponderous Spar.

This stone is of a white, grey, or yellowish white colour, and sometimes reddish ; sometimes

times not harder than chalk, but mostly very compact, and of a stony hardness, though never so hard as to give fire with steel. Its texture lamellar or fibrous; its shape either amorphous, orbicular, tabular, or cristated, that is, jagged like a cock's comb, or crystallized in polygon prisms: it is also found opaque, semi-transparent, or transparent; this last sort is an electric *per se*.

Its specific gravity is generally from 4 to 4.6, though sometimes, as Mr. *Wiegleb* remarks, it is not so great. 11 *New. Endeck*, 15.

It is insoluble, or nearly so, in water, as well as in acids.

The harder sorts decrepitate in fire; it does not burn to Plaster of Paris as gypsum does; it is infusible *per se* with a blow-pipe, yet Mr. *D'Arcet* found the semi-transparent sort fusible in a long continued porcelain heat. 22 *Roz.* 26; probably because it was placed in an argillaceous vessel: but it is fusible by the help of the mineral alkali, with effervescence, and also with borax and microcosmic salt, according to Mr. *Bergman*.

It is often mixed with calcareous Earth,
6 *Roz.* 222. 13 *Roz. Supplement*, p. 408.

Mr. *Morveau* observes that it accompanies the ores of most metals. Mr. *Margraaf* also frequently found masses of it mixed with gypsum. 1 *Margr.* 332.

The easiest method of decomposing it, is that practised by Mr. *Wolfe* and Mr. *Wiegleb*, viz. by calcining it in a strong red heat for 1 or 2 hours, with $1\frac{1}{2}$ or twice its weight of fixed alkali; the neutral salt and superfluous alkali are then washed off, and the Earth is found combined with fixed air. Mr. *Morveau's* method is cheaper. He calcines the ponderous spar with $\frac{1}{6}$ of its weight of charcoal for 1 hour, in a crucible, well luted, and a strong red heat: he then dissolves the Earth in the acetous acid. The sulphur is thus separated. *Mem. Dijon*, 1782. Mr. *Margraaf* decomposed it in the liquid way, by mixing two parts of the stone with one of fixed alkali; then pouring hot water on it, and keeping it boiling for some hours. 1 *Margr.* 366. The decomposed part, welledulcorated, is soluble in acids.

This species often forms the stony matter of petrifications. *Mem. Dijon*, 1782. 1 *Semest.* p. 163.

According to Mr. *Bergman*, 100 parts of it contain 84 of Earth, 13 of the most concentrated

Barytical Genus.

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centrated acid, and 3 of water. 100 parts of artificial baroselenite contain about 33 of vitriolic acid and water, and 67 of Earth.

Some species, particularly the red, contain 1 or two gr. of iron per cent.

SPECIES III.

Combined with the Sparry Acid.

This combination has not yet been found in nature; that formed by art is nearly insoluble in water.

SPECIES IV.

Combined with the Tungsten Acid.

This combination is also insoluble in water, but it has not as yet been found.

SPECIES V.

Mild Barytes intimately mixed with a notable Proportion of Silex and Iron.

I mention this species on the authority of Mr. Bindheim. 4 *Berlin Schrift.* 397. It is insoluble in acids, and of a sparry texture; but, as he says it becomes soluble after calcination with oil, I should be inclined to judge it rather a baroselenite.

SPECIES VI.

SPECIES VI.

Baroselenite mixed with a notable Proportion of Silex, Mineral Oil and Terrene Salts, Liver Stone, Lapis Hepaticus.

It's colour is white, grey, yellow, brown, or black; it is generally compact, but not so hard as to give fire with steel; its texture is either equable or laminar, scaly or sparry, and it takes a polish as alabaster.

It does not effervesce with acids.

When calcined, it is partially reduced to a sort of Plaister of Paris.

It emits a smell of *hepar sulphuris*, at least when rubbed,

According to Mr. *Bergman*, 100 parts of it afford 33 of baroselenite, 38 of silex, 22 of alum, 7 of gypsum, and 5 of mineral oil. The increase proceeds from the water of chrysalization.

C H A P. VI.

Muriatic Genus.

Under this genus I include not only those Earths and Stones in which magnesia predominates, but also those in which the siliceous
genus

genus predominates, if magnesia be, next to the siliceous, the most copious ingredient, and the compound possesses the characters of the muriatic, and not those of the siliceous genus.

SPECIES I.

Combined with the Aerial Acid, and barely mixed with other Earths, in an earthy, or semi-indurated Form.

Pure magnesia has no where yet been found, nor even magnesia, barely combined with fixed air, and free from all mixture of other Earths. When combined with fixed air by art, 100 parts of it contain at a medium 30 of aerial acid, 48 of mere Earth, and 22 of water; but these proportions are variable within certain limits, the fixed air being found in the proportion of from 25 to 37, the Earth from 40 to 48, and the water from 20 to 30. in general when the proportion of fixed air is greatest, that of water is smallest, and *vice versa*.

I. VARIETY.

Mixed with Siliceous Earth.

*Spuma Maris, Meershaum of the Germans.
Keffekill.*

This is found in various parts of the world, particularly in the East, in veins of moderate thickness,

thickness, and is the substance of which the large Turkey tobacco-pipes are formed : it is probably found also in *North America*, being the substance called in *Canada*, *Terre a chalu-meau*. It is of a white or yellow colour, soapy feel, and moderately hard. It hardens easily in fire without requiring a great heat. In the state in which we receive it, that is baked, it does not effervesce with acids, and is difficultly soluble therein.

According to Mr. *Wiegleb's* analysis, it consists of equal parts, magnesia and flex. 5 *Crell. Nev. Entdeck*, p. 3.

II. VARIETY.

Mixed with Calcareous Earth and Iron.

It appears like an olive-coloured, or blue clay : the olive-coloured contains no argillaceous Earth : the blue sort contains most calcareous Earth, also iron, a little argill, and petrefactions. Both are found near *Thionville*. The former sort is used in pottery. 13 *Roz.* p. 60.

III. VARIETY.

Mixed with Clay, Talc., and Iron.

This is a greenish yellow, loose Earth, of a greasy feel, found in *Silesia*. It contains

tains $\frac{1}{3}$ of its weight of magnesia. • *Margraaf*, 2 *Theil*. p. 18.

SPECIES II.

Combined with Aerial Acid, above four times its weight of Silix, and a smaller proportion of Argill.

I. VARIETY.

Steatites.

This is always of a green or greenish colour, and so soft as to be scraped by the nail; of a soft soapy feel: its texture undistinguishable; its specific gravity from 2,433 to 2,78. It is not easily diffusible in water, nor rendered ductile by mixture with it.

It does not effervesce with acids, and is very slowly and only partially soluble in the three mineral acids.

In fire it hardens, but is infusible *per se*, and becomes whiter. It is imperfectly melted by mineral alkali and microcosmic salt, but more perfectly by borax. It is apt to corrode the crucibles.

According

According to Mr. *Bergman's* analysis, 100 parts of it contain 80 of *filex*, 17 of mild *magnesia*, 2 of *argill*, and nearly 1 of iron in a semiphlogisticated state.

II. VARIETY.

Soap-rock, Lapis Ollaris, Pot-stone, Speckstein of the Germans, Spanish Chalk. 2 Margr. 14.

This is of a *yellow* colour, and sometimes whitish, and but rarely black: it is also somewhat harder than the former variety, and probably the proportion of *argill* is somewhat greater, but in other respects it perfectly resembles it. The black contains a mineral oil.

This stone is easily worked and turned, in-
somuch that pots and mortars are often made of it.

Mr. *Gerhard* remarks, that the Swedish *speckstein* often effervesces with acids, and contains calcareous Earth, but that of *Saxony* and *Silesia* never. The limestone is merely an accidental mixture. 4 *Berlin, Schrist.* 300.

SPECIES III.

SPECIES III.

Mild Magnesia combined with Silex, Calcareous Earth, and a small proportion of Argill and Iron.

I. VARIETY.

Fibrous Asbestos, Alumen Plumosum.

The colour of this stone is generally greenish, and it consists of filaments either parallel to, or interwoven with each other. It is rough to the touch, and brittle and uneven in its fracture, hence it does not strike fire with steel. Its specific gravity is from 2,5 to 2,8.

It does not effervesce with acids, and is soluble in them but partially, and by particular management.

When sufficiently heated, it becomes somewhat whiter and more brittle, but is infusible *per se* by the blow-pipe, unless it contains a notable proportion of calx of iron. It is difficultly fusible with mineral alkali, more easily with borax and microcosmic salt, and with scarce any effervescence. It is never transparent, and in that respect, and in the unevenness of their fracture only, some sorts
of

of martial asbestos differ in external appearance from some sorts of shoerl.

According to Mr. *Bergman*, this variety contains from 53 to 74 parts of filex, from 12 to 28 of mild magnesia, from 7 to 14 of mild calcareous Earth, from 2 to 6 of argill, and from 1 to 10 of iron *per cent.* 100 parts martial asbestos contain 62 of filex, 13,7 of magnesia, 12 of calcareous Earth, 1,7 of argill, and 10,6 of iron ; yet it gives in fusion a white flagg.

II. VARIETY.

Coriaceous Asbestos, Suber Montanum, Aluta Montana, Mountain Cork, Leather, &c.

This sort of asbestos resembles in texture those substances from which it borrows these fanciful appellations. It is easily distinguished by its elasticity and lightness, for it floats a long time on water. In other respects it resembles the former species, except that its colour is either white, yellow, brown, green, or black.

100 parts of it contain from 56 to 62 of filex, from 22 to 26 of mild magnesia, from 10 to 12 of mild calcareous Earth, from 2 to 2,8 of argill, and about 3 of iron.

SPECIES IV.

SPECIES IV.

Mild Magnesia combined with Silex, mild Calcareous Earth, Barytes, Argill and Iron.

Amianthus.

In structure this species resembles the first variety of the foregoing; consisting of long parallel fibres, in some degree flexible, and soft to the touch. The surface of its fracture is also uneven. Its colour, white, grey, greenish or reddish: its specific gravity 2,913.

It does not effervesce with acids, and is difficultly, and but partially soluble therein.

It is fusible *per se* in a strong heat, and also with borax, microcosmic salt, and mineral alkali, with effervescence. In fusion it again chrystalizes in filaments, but in a still stronger heat it forms a green glass, which corrodes the crucibles, as Mr. *Saussure* has observed.

100 parts of the *Amianthus* of *Tarentaise* examined by Mr. *Bergman*, afforded him 64 of silex, 18,6 of magnesia, 6,9 of calcareous Earth, 6 of barytes, 3,3 of argill, and 1,2 of iron.

SPECIES V.

Pure Magnesia combined with something more than its own weight of Silix, about $\frac{1}{3}$ of its weight of argill, nearly $\frac{1}{3}$ of its weight of water, and about 1 or 2 tenths of its weight of Iron.

Serpentine, Lapis Nephriticus, Gabro of the Italians.

In respect to colour, as well as composition, this stone is susceptible of great variety, for it is found either white, green, brown, reddish brown, yellow, light blue, black, spotted, or streaked with veins of different colours. Its texture is either indistinct, obscurely laminar, or fibrous. It is harder than soap-rock, but not so hard as to give fire with steel, and less smooth to the touch, but susceptible of a good polish, looks like marble, and is often in thin pieces semi-transparent.

Its specific gravity is from 2,4 to 2,65.

It does not effervesce with acids, but is slowly and partially soluble in them.

It melts *per se* in a strong heat, and preys on the crucibles. *Vogel*, 103. In a lower degree of heat it hardens.

According

According to the analysis of Mr. Bayen, 100 parts of it contain about 41 of filex, (which he takes rather to be mica) 33 of magnesia, 10 of argill, 12 of water, and about 3 of iron. The serpentine of Corfica contains a larger proportion of argill and a smaller of filex.

The greener sorts of this stone have been called *nephritic*.

SPECIES VI.

Pure Magnesia intimately mixed with nearly twice its weight of Silex, and less than its own weight of Argill.

Venetian Talc.

Its colour is white, grey, yellowish, or greenish: it is soft and soapy to the touch, and in thin pieces semi-transparent: it is composed of very thin laminæ disposed in a laminar or filamentous form, much tenderer and more brittle than those of mica, but like this it has a metallic lustre: its hardness is so inconsiderable that it may be scratched with the nail: its specific gravity is 2,729.

It does not effervesce with acids, and is soluble therein very difficultly by particular management, and only in part.

In fire it becomes more brittle and whiter, but is infusible *per se* by the blow-pipe, and scarcely fusible by fixed alkalis, but more completely, and with little effervescence, by borax or microcosmic salt.

This talc contains something less than 50 per cent. of silica, and about 2 per cent. of iron. The magnesia is in smaller quantity, but it exceeds the argill: the exact proportion I have not found.

Muscovy talc consists of broad, elastic, flexible, transparent leaves, and differs externally from mica only in being softer and more soapy to the touch.

SPECIES VII.

Combined with the Sparry Acid.

This combination is scarcely soluble in water, but has not yet been discovered in nature.

SPECIES VIII.

Combined with the Tungsten Acid.

This compound when artificial is also insoluble, but has not as yet been observed native.

Compound.

Compound Species in which the Muriatic Genus predominates.

SPECIES I.

Compounds of the different simple Muriatic Species with each other.

I. VARIETY.

1. Steatites mixed with Talc, *Craie de Briançon*. It is generally grey, yellow, or greenish: it seems more argillaceous than pure steatites, and contains more iron. *M^r. D'Arcet* found it fusible in a porcelain heat.

II. VARIETY.

1. Serpentine mixed with veins or spots of green Steatites.

2. Red Serpentine mixed with veins of Asbestos.

SPECIES II.

Compounds of the Muriatic and Calcareous Species.

1, Red, green, yellow, or black Serpentine, with veins or spots of white Calcareous Spar *Potzevera*. The black is called *Nero di prato*;

the green *Verde di Suza*; but these names are not restrained to this species.

2. Serpentine with veins or spots of Gypsum.

SPECIES III.

Compounds of the Muriatic and Barytic Species.

I. VARIETY.

Serpentine with veins or spots of barosele-nite.

SPECIES IV.

Compounds of the Muriatic and Argillaceous Species.

I. VARIETY.

1. Steatites mixed with a notable proportion of indurated Clay. It is less soft to the touch, and something harder than the pure steatites: its colour is grey or greenish brown: it frequently contains also mica or talc, and sometimes a notable proportion of iron, and then it is red. The talcose is frequently called French chalk, or *Craie de Briançon*.

2. Steatites.

Muriatic Genus.

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2. Steatites mixed with Shiftus, or bituminous Shiftus. This is blue or black, and rougher to the touch than pure steatites.

3. Serpentine mixed with veins or spots of Shiftus.

4. Soap-rock mixed with Mica. *Cronst.*
§ 265. Grey, yellow, or greenish.

SPECIES V.

Compounds of the Muriatic and Siliceous Species.

1. Serpentine with veins of Quartz or Felspar, or Shoerl.

C H A P. VII.

Argillaceous Genus.

SPECIES I.

Saturated with Aerial Acid.

Lac Lane.

This fanciful name was heretofore thought to denote a very fine species of calcareous Earth, but Mr. *Schreber* has lately shewn that the Earth to which this name is given, is a very uncommon species of argill. It is generally found in small cakes of the

F 4

hardness

hardness of chalk, and like that, it marks white: its hardness is nearly as that of steatites, and does not feel as fat as common clay does: its specific gravity is 1,669: its colour is snow white. When examined with a microscope, it is found to consist of small transparent crystals; and by his experiments it plainly appears to be an argill saturated with fixed air. It effervesces with acids, and contains a very small proportion of calcareous Earth, and sometimes of gypsum, and some feeble traces of iron. It is found near *Halles*. 15 *Naturforsch.* 209.

SPECIES II.

Combined but not saturated with Aerial Acid, in a loose or semi-saturated form, and mixed with fine Quartz or Silex in various proportions, a small quantity of Water, and generally of Iron.

Clay, Creta of the Italians.

This species receives a number of different denominations, arising from its hardness, fusibility or infusibility, or the different uses it is applied to, or relative to its colour, or origin; such as stone clay or lithomarga, fusible or apyrous clay, marl, Fuller's earth, pipe clay, kaolin, brick clay, umber, coloured clays, boles, pouzzolana, terras, tripoli, &c. All
clays

clays are more or less easily diffusible in water, which they imbibe with more or less avidity, according to their previous compactness, and if they contain much air they froth with water, burst and fall to pieces: when they have imbibed it they are more or less ductile and viscid, according as the sand they are mixed with is more or less fine. They contract in drying, and crack: when heated, they contract still more, and harden to such a degree as to give fire with steel. They do not effervesce with acids, unless they contain magnesia or calcareous Earth. The finer clays have a smooth, and in some measure, a soapy feel.

These are the properties of pure argillaceous Earths; yet most clays contain but from 25 to 48 per cent. of this Earth, the remainder consists of fine siliceous Earth, and a little water. On the subtilty and purity of the siliceous part, the fineness of clay principally depend.

Many clays contain a little volatile alkali, and some the vitriolic acid; probably this latter is united to the argill in the state of embryon alum. that is, in such proportion as not to render it soluble in water. Most of them contain also a small proportion of iron.

Fusible

Fusible Clays.

All clays, which, besides argillaceous and siliceous Earths, contain a mixture of calcareous or muriatic Earths, or gypsum, or fluor, or felt spar, or iron, are more or less fusible, according to the proportion of these foreign ingredients.

Apyrous Clays.

Clays that consist of argillaceous and siliceous Earths singly, without any mixture of iron or other metallic substance, or at least only in an inconsiderable proportion, are infusible. Such is that found near *Plombiere*. *Mem. Par.* 1778, p. 433.

Argillaceous Marl.

Any clay that contains from 20 to 50 per cent. of mild calcareous Earth, comes under this denomination. It differs prodigiously in point of hardness and colour: the hardest is called *lithomarga*, or stone marl. The best for agriculture is the grey or white; the coloured generally contain metallic particles: when it contains 20 or 30 per cent. of calcareous Earth it is fusible *per se*. The coloured marls, as they contain more iron, are still
more

more fusible. This species of marl falls to pieces more difficultly, either in water or air, than calcareous marl.

Indurated marls, of a quadrangular form, have been called *Ludi helmontii*.

Fuller's Earth.

This is mostly of a white, grey, bluish, or yellowish colour, compact, semi-indurated, of a lamellar texture, and often conchoidal in its fracture; consisting of very fine particles, smooth and somewhat soapy to the touch: it bursts and is diffusible in water, with which it often froths like soap: it does not effervesce with acids; in a strong heat it melts into a slag. Microcosmic salt affects it but slightly; mineral alkali more powerfully, and with much effervescence, but borax melts it most completely.

Different specimens of it, from various countries, afforded Mr. *Bergman* from 47 to 60 of siliceous Earth, from 11 to 25 of argillaceous, from $\frac{1}{2}$ to 6 parts of magnesia, from 3 to 7 of mild calcareous Earth, from 3 to 5.5 of dephlogisticated iron, and from 15 to 18 of water, mixed with a very minute proportion of marine acid; but this last was found only in a few of them. Its fulling
power

power arises from the property of clay to absorb oils, the fineness of its particles, which do not injure the cloth, and its easy diffusibility in water, which renders it capable of being washed off.

Terra lemnia is a yellowish or flesh-coloured clay of this sort.

Pipe Clay.

Any moderately pure and fine white clay, which retains its colour in fire, is distinguished by this appellation. That of *Cologne* is the purest, and is infusible in the strongest heat. Many of these clays become grey in a weak degree of heat, because the mineral oil with which they are mixed burns to a coal, but in a stronger heat they again become white, this coal being consumed.

Porcelain Earth, or Kaolin.

This differs from the former chiefly in the fineness or subtilty of the siliceous ingredient. It sometimes effervesces with acids, either because it contains crystalized argill, or magnesia, or calcareous Earth: it also abounds in talcose particles. It never contains any oily matter, and therefore retains its colour in every degree of heat.

Brick

Brick Clay.

Its colour is various, reddish, bluish, or yellowish: it always contains iron, and melts into a slag. The best sort contains little or none of calcareous Earth, but a good deal of a coarse siliceous sand.

Coloured Clays.

Yellow, red, and brown clays contain most iron, sometimes dispersed through them, and sometimes united to the siliceous part: in this case they are more difficultly fusible. The yellow calx of iron is more dephlogisticated than the red, and the red more so than the brown. When these clays contain about 14 or 15 per cent. of iron; they become magnetic after calcination.

Red chalk, Rubrica fabrilis, is, according to Mr. Rinman, either a clay intermixed with the red calx of iron, which hardens in fire, and then becomes magnetic and browner, and in a stronger heat melts into a black glass, and contains from 16 to 18 per cent. of iron, (but sometimes it contains but 7 or 8 per cent. of iron, and then does not become magnetic by roasting) or it is an impure steatites, mixed with clay and calx of iron. *Historia Ferri*, § 189.

Blue

Blue Clays.

These sometimes lose their colour and become white when heated, and consequently contain but little of iron, but owe their colour to an oily matter, which is dissipated by heat; others owe their colour, according to Mr. *Monnet*, to a mixture of pyrites. *Mineralogie*, p. 339. Mr. *Beaumé* says, that blue clays contain the vitriolic acid, but he probably found it only in the pyritical clays, for in other sorts Mr. *Woulfe* could discover none. *Phil. Transf.* 1779, p. 20. Mr. *Bergman* found some which contained copper and a little of cobalt. *Rinman* mentions a blue lithomarga, which contained 13 per cent. of iron, 4 of lead, and some vestiges of zinc. *Hist. Ferri*, § 201, p. 712.

Umber.

A brown or blackish substance, which stains the fingers, and is very light; it has long been taken for a clay, but Mr. *Hupfch*, *Mem. Berlin*, 1777, has discovered it to consist of particles of decayed wood, mixed with bitumen; yet it is certain that this name hath also been given to a sort of brown ochre, of the same colour, which becomes red when slightly heated, but in a stronger heat is again brown and magnetic, and in a still stronger melts into a black glass. It does not effervesce with acids
before

before roasting, but after that the martial part is soluble.

Green Clays.

Some forts are said to redden in fire, and contain iron. Mr. *Bergman* has found some which contain copper and cobalt ; to separate which he precipitated the copper by iron, and digested the residuum in distilled vinegar. Other forts are said to contain nickel.

Black Clays.

These are said to be bituminous.

Variegated.

The most remarkable of this species is the *Terra miraculosa Saxonie*, which is a beautiful indurated clay, of a purplish colour, with white, yellow, red, or brown veins or dots.

Bole.

Is a term of uncertain signification, and should therefore be banished. Some bestow this name on very smooth compact clays, consisting of the finest particles : others require besides, that their colour should be red, yellow, or brown, and that they should contain iron. The red generally blacken in fire, 2
Bergm.

Bergm. 476, yet do not become magnetic. *Rinman*, § 189. The yellow, when heated, become first red, and in a strong heat, brown or black. *Calamita bianca* of the Italians is a white bole, striated like asbestos. *Ferber, Italy*, 122. *Terra sigillata rubra* contains calcareous Earth, and becomes magnetic after torrefaction. *Rinman*, § 189.

Of Volcanic Origin.

Pouzzolana.

This is of a grey, brown, yellowish, or blackish colour, loose, granular, or dusty, and rough, porous and spongy, resembling a clay hardened in fire and then reduced to a gross powder. It contains, mixed with it, various heterogenous substances: its specific gravity is from 2,5 to 2,8, and it is in some degree magnetic: it scarcely effervesces with acids, though partially soluble in them: it melts easily *per se*: but its most distinguishing property is, that it hardens very suddenly when mixed with $\frac{1}{3}$ of its weight of lime and water, and forms a cement, which is more durable in water than any other. According to Mr. *Bergman's* analysis, 100 parts of it contain from 55 to 60 of siliceous Earth, 19 or 20 of argillaceous, 5 or 6 of calcareous, and from 15 to 20 of iron. 3 *Bergm.* 193. It is evidently a martial argillaceous marl that

that has suffered a moderate heat. Its hardening power arises from the dry state of the half-baked argillaceous particles, which makes them imbibe water very rapidly, and thus accelerates the defication of the calcareous part; and also from the quantity and semi-phlogisticated state of the iron contained in it. It is found not only in *Italy* but also in *France*, in the provinces of *Auvergne* and *Limoges*, and also in *England*, and elsewhere.

Traafs, or Terras.

This differs but little in its principles from pouzzolana, but is much more compact and harder, porous and spungy. It is generally of a whitish yellow colour, and contains more heterogenous particles, as spar, quartz, shoerl, &c. and something more of calcareous Earth: it effervesces with acids, is magnetic, and fusible *per se*. When pulverized, it serves as a cement, like pouzzolana. It is found in *Germany* and *Sweden*.

Tufa.

Volcanic ashes concreted with various other species of stone, but in which argill predominates, forms the stone thus called: it is harder than traafs, but still porous and spungy.

White Volcanic Earth.

That of *Solfatera*, examined by Mr. *Bergman*, was found to consist chiefly of filix, mixed with about 4 per cent. of argill, and 8 per cent. of allum. 3 *Bergm.* 198.

Tripoli.

Its colour is either white, grey, yellow, reddish, or brown, either indurated and brittle, or loose, powdery, and rough: it does not soften in water, nor effervesce with acids. According to Mr. *D'Arcet*, it is vitrifiable *per se* in a porcelain heat long continued; and according to Mr. *Bergman*, it yields to borax and microcosmic salt, but scarcely to fixed alkali.

Mr. *Haase*, who has lately analysed it, found 100 parts of it to contain 90 of siliceous Earth, 7 of argill, and 3 of iron; but the red sort probably contains more iron. According to Mr. *Gerhard*, magnesia has sometimes been extracted from it.

It is evidently a volcanic product; for a coal mine near *St. Estienne* having accidentally taken fire, and the fire in its progress having extended to some strata of shistus and bitumen, tripoli was found in those parts of the strata that

that the fire had acted upon, but not in any other. *Mem. Par.* 1769, p. 276.

The *rotten stone* of *Derbyshire* is, according to Mr. *Ferber*, a tripoli mixed with calcareous Earth.

SPECIES III.

Barely saturated with Vitriolic Acid.

Embryon Allum.

This species was first discovered by Mr. *Beaumè*; it forms small scaly chrystals like mica, which require 1450 times their weight of water to dissolve them in the temperature of 60°. It is no where found single, but generally mixed with clays, from which it may be separated by boiling, and dissolved in water, to which it gives an earthy taste, and is separable by the affusion of lime water, which precipitates the argill.

SPECIES IV.

Barely saturated with Marine Acid.

Embryon Marine Allum.

As a solution of marine alum, completely saturated with argill, forms also a very difficultly

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cultly soluble compound, and as many clays are found to contain the marine acid, it is probable that this species exists in them, though it hath not yet been noticed.

In a stony Form.

Under this head I comprehend all those stones which, although the siliceous genus predominates in their composition, and the argillaceous, with respect to quantity, obtains only the second place, yet do not possess the character of siliceous stones, as they do not strike fire with steel; and on the contrary, I exclude those which possess the characters of siliceous Earths, though they contain the argillaceous in greater quantity.

SPECIES V.

Argill combined with 1,36 its weight of Silex, 0,7 of its weight of pure Magnesia, and 0,5 of its weight of highly dephlogisticated Iron.

Pure Mica.

This stone, in its purest state, is colourless; but either from a less intimate combination, or from a mixture of some superfluous ingredient, principally iron, it is found of different colours, white, red, yellow, green, brown, or black, (the white and yellow sort have

have a splendid metallic appearance) smooth, but not greasy to the touch, which distinguishes it from talc. Its texture is always lamellar or scaly, and the lamellæ, or scales, are slightly flexible and often elastic; these scales are sometimes parallel to each other, sometimes interwoven, sometimes wavy, or undulated, and sometimes they represent filaments. Its specific gravity is from 2,535, to 3,000 when loaded with iron.

It does not effervesce with acids, and is insoluble in them without particular management, but after it has been calcined with 4 times its weight of fixed alkali, it effervesces strongly, and is in great measure soluble.

The pure colourless mica is infusible *per se*, and scarcely melts even with mineral alkali, but yields more readily to borax or microcosmic salt, with scarce any effervescence; but the coloured sorts were found by Mr. *Saussure* to be fusible *per se*, though with difficulty, for they require a stronger heat than shoerl does.

100 parts of the colourless kind contain 38 of silex, 28 of argill, 20 of magnesia, and 14 of the most dephlogisticated calx of iron. Martial mica contains besides, 10 or 12 per cent. of a more phlogisticated

calx of iron, from whence its various colours are derived, and a proportionably smaller quantity of the other ingredients.

Argillaceous Fissile Stones.

These and many other of different genera, have been comprehended under the denomination of *Schisti*, but to avoid ambiguity, I think it expedient to confine this name to stones of the argillaceous genus.

SPECIES VI.

Roof Slate, Schistus Tegularis.

Of this species there are many varieties, none of which have been hitherto analysed, except the bluish purple slate chiefly used here, which I have lately examined, and to which, as to a standard, I shall refer the other sorts.

I. VARIETY.

Argill intimately mixed with 1,77 of its weight of Siliceous Earth, 0,3 of its weight of Magnesia, 0,15 of Calcareous Earth, both slightly aerated, and nearly 0,54 of its weight of Iron, besides a slight admixture of Mineral Oil.

Bluish Purple Slate.

It does not strike fire with steel, and may be slightly scraped with the nail: it is very brittle,

brittle, and of a lamellar texture: its specific gravity is 2,876: when in pieces of $\frac{1}{2}$ of an inch thick, or less, it gives a clear sound if struck: its grain is moderately fine: it is never transparent: it slightly effervesces with acids when reduced to powder, otherwise not: when heated red, it loses something more than 2 per cent. of its weight, slightly detonates with nitre, and then assumes a brownish red colour, but calcination does not render it magnetic: in a stronger heat it is fusible *per se*, and forms a black scoria: it is difficultly dissolved by mineral alkali in the dry way, more easily by borax, though with little effervescence, and also by microcosmic salt with some effervescence. Mr. Gerbard remarks, that it melts with equal ease in chalk or clay vessels.

Dephlogisticated spirit of nitre, after standing on it two months in cold, assumes a green colour,

I found 100 gr. of it to contain about 46 of silex, 26 of argill, 8 of magnesia, 4 of calcareous Earth, and 14 of iron. Part of the iron seems to be in a phlogisticated state, from its union with the oil, and part in a dephlogisticated state, or that of a red calx. This is united to the argillaceous part and silex, and is very difficultly separated.

II. VARIETY.

Pale, slightly Purple, or bluish Shistus.

This stone is harder than the foregoing, its laminæ thicker, and its texture coarser; it seems to contain a larger proportion of the siliceous and a smaller of the martial ingredient.

III. VARIETY.

Blue Shistus.

The proportion of the earthy ingredients being the same as in the first variety, that of the martial ingredient seems to be smaller.

Other stones are also used for covering houses in various countries, but they are easily distinguished; as their laminæ are much thicker, their surface more uneven, and their texture coarser. They chiefly belong to the class of sand-stones, or to the calcareous genus.

IV. VARIETY.

Dark Blue Slate, Shistus Scriptorius.

It effervesces more briskly with acids, and seems to contain more magnesia, and less iron,
than

than the first variety : its specific gravity is 2,701.

SPECIES VII.

Argillaceous Earth mixed with a variable Proportion of Pyrites, with a little Magnesia and Calcareous Earth.

Pyritaceous Schistus.

Its colour is grey, brown, blue, or black : it is more or less decomposable by exposure to the air, according to the quantity of the pyritous ingredient and the state of the iron in the pyrites ; if the iron be in a semiphlogisticated state it is easily decomposed, but if the calx of iron be already much dephlogisticated, it will be decomposed but slowly, if at all. *Aluminous schistus* is of this species, but will more properly be mentioned in treating of alum.

SPECIES VIII.

Slate, or Pyritaceous Schistus, intimately mixed with a notable Proportion of Mineral Oil or Bitumen.

Bituminous Schistus.

It is generally black, of a lamellar texture, of different degrees of hardness, but never gives

gives fire with steel: it emits a strong smell when heated, and sometimes without heat; does not shew white when scraped.

SPECIES IX.

Argill mixed with from 3 to 4 tenths of its weight of Silex, and a little of the yellow or red Calx of Iron.

I. VARIETY.

Argillaceous Shistus, Flag-stone.

This is of a grey, yellowish, or reddish white colour; does not give fire with steel, nor effervesce with acids: its specific gravity is from 2,6 to 2,78: it is in some places used for covering of houses, but mostly for flooring: it is sometimes compact, and sometimes sandy, like the next variety, and then its specific gravity is smaller.

II. VARIETY.

Argillaceous Grit, Free-stone, or Sand-stone.

It is called free-stone because it may be cut easily in all directions: its texture is more or less porous, equable and rough to the touch: it exhales an earthy smell when fresh broken and breathed upon: it does not give fire with steel, nor effervesce with acids.

That

That from *Hollington*, near *Utoxeter*, is of a whitish or yellowish grey, and its specific gravity 2,288. That from *Knipersly*, in *Staffordshire*, is of a bluish grey, and so infusible as to be used for a fire-stone : its specific gravity is 2,568.

SPECIES X.

Argillaceous Earth intimately mixed with 1,7 of its weight of Silex, about 0,7 of its weight of mild Magnesia, 0,09 of its weight of mild Calcareous Earth, and about its own weight of semiphlogisticated Calx of Iron.

Horn-stone, Hornblende of Cronsted, and Talcum Striatum of Rinman, Mem. Stockh. 1754.

The general characters of this stone, besides a partial solubility (though without effervescence) in acids, and a hardness never sufficient to strike fire with steel, properties which are common to it with the former species,) are 1st. a specific gravity never less than 2,66, and frequently rising to 3,88. 2^d. a strong earthy smell which it exhales on being breathed upon, or having hot water poured on it : 3^d. a toughness or viscosity perceived in pounding it in a mortar, like mica or horn, from whence it derived its name: 4th. its affording a greenish grey powder when pounded :
ed :

ed; 5th. fusibility *per se*, as it is said, though I could not melt it with the blow-pipe. It is frequently mixed with pyrites.

I. VARIETY.

*Black Horn-stone, Corneus Nitens Waller,
Sp. 169.*

Its texture is lamellar or granular; the former is sometimes so soft as to be scraped with the nail; its surface frequently as glossy as if it had been greased: its specific gravity is from 3,6 to 3,88; it possesses besides all the specific properties above-mentioned in a high degree: it does not detonate with nitre: it becomes of a snuff colour when heated, and then slightly effervesces with diluted nitrous acid: its solution in this acid is of a greenish colour.

In order to discover the principle on which its smell depends, I boiled its powder in water, but did not find the water altered in taste, nor did any test I applied shew any change in it.

I found 100 gr. of the lamellar sort to contain 37 of flint, 22 of argill, 16 of magnesia, 2 of calcareous Earth, (both in a mild state) and 23 of calx of iron, not much dephlogisticated.

II. VARIETY.

II. VARIETY.

Greenish Grey Horn-stone.

This is of a granular texture, or striated; the specific gravity of the purest specimen I examined is 2,683: it is not so soft as the softest of the former variety.

I suspect the common pale greenish grey whetstone to be of this species: it is of a close granular texture, exhales an earthy smell, affords a greenish powder, does not effervesce with acids, nor give fire with steel; its specific gravity is 2,664; it contains 65 per cent. of flint.

III. VARIETY.

Killas.

This stone is chiefly found in *Cornwall*; its colour is pale grey or greenish grey; its texture either lamellar or coarsely granular: the lamellar is softer and less martial than the roof shistus: its specific gravity from 2,63 to 2,666.

I found 100 grains of the lamellar sort to contain about 60 of flint, 25 of argill, 9 of magnesia,

magnesia, and 6 of iron. The greenish sort contains more iron and gives a greenish colour to the nitrous acid.

SPECIES XI.

Argillaceous Earth intimately mixed with 4 times its weight of Siliceous, $\frac{1}{2}$ its weight of pure Calcareous, and something more than its weight of Iron.

Toad-stone.

Dr. *Withering*, who has given us an analysis of this stone, describes it as being of a dark brownish grey colour, of a granular texture, not giving fire with steel, nor effervescing with acids: it has cavities filled with chrystalized spar: it is fusible *per se* in a strong heat. *Phil. Trans.* 1782, p. 333.

100 parts of it contain 63 of siliceous Earth, 14 of argillaceous, 7 of calcareous, and 16 of dephlogisticated iron: it differs but little from basalt; it is softer, contains a smaller proportion of iron, and a larger of silex.

SPECIES XII.

SPECIES XII.

Argill united to 2, 3, or 8 times its weight of Silex, about half its weight of pure Calcareous Earth, and from once to twice its weight of Water, without any Iron, except accidentally.

Zeolyte.

This stone is found of different degrees of transparency, or perfectly opaque, either colourless, whitish, yellowish, greenish, or reddish; its shape is either pyramidal, columnar, tabular, oval, capillary, or amorphous; its texture either granular, scaly, or radiated; the filaments diverging as from a central point, or indistinguishable.

It does not give fire with steel.

Its specific gravity is from 2,1 to 3,15, but this last is very rare.

It does not effervesce with acids, though it is partially soluble in them, but if inserted into a proper proportion of concentrated nitrous acid, it forms a gelatinous mass, arising from the suspension and diffusion of the siliceous Earth contained in it; but this property is not peculiar to zeolyte, as Mr. Pellatier has shown,

shewn. 20 *Roz.* 429. And some few zeolites do not become gelatinous. 3 *Bergm.* 228.

When exposed to a strong heat it dilates and swells, more or less, according to the proportion of water contained in it, and afterwards melts *per se*, more or less easily, according to the proportion of calcareous Earth, into a frothy slag; in the moment of fusion it is said to become phosphorescent; it also melts easily, and with effervescence, with mineral alkali; something more difficultly with borax, but microcosmic salt has scarce any effect on it. When in fusion, it scarcely injures the crucibles. 22 *Roz.* p. 29. This dilatibility is the surest criterion whereby to distinguish zeolites. The Upland zeolites are difficultly fusible.

According to Mr. *Bergman's* analysis, the red zeolyte of *Adelfors* contains 80 per cent. of siliceous Earth, 9,5 of argillaceous, 6,5 of pure calcareous Earth, and 4 of water. *Van Troil's Letters*, p. 370.

The white, oval, radiated zeolyte of *Fero*, contains, according to Mr. *Pelletier*, 50 of flint, 20 of argill, 8 of pure calcareous Earth, and 22 of water. 20 *Roz.* 420. Mr. *Meyer* found another of the radiated sort to contain

Argillaceous Genus.

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contain 58,33 per cent. of siliceous, 17,5 of argill, 6,66 of lime, and 17,5 of water. 4 *Berlin Beschäft.* p. 330. In general the crystalized sorts contain more water than the amorphous. Mr. *Bergman* found the zeolyte of *Jemmland* to contain 16 per cent. of calcareous Earth, and that of *Fero* to contain 25 per cent. of argill, so that the proportions are very variable.

SPECIES XIII.

Of Volcanic Origin.

Argillaceous Earth imperfectly united to 4 times its weight of Siliceous, and $\frac{1}{3}$ of its weight of Iron.

Pitch-stone, Lava.

It is of a greyish, greenish, black, red, or brown colour, has the glassy appearance of a semi-vitrified substance, and melts easily *per se*: it often contains substances seemingly heterogenous: some pieces of it do not give fire with steel, and therefore belong to this genus, others do, and belong therefore to the siliceous genus,

According to Mr. *Wiegley's* analysis, 11 *Nev. Endeck*, p. 18, 100 parts of it contain

H

65

98 *Elements of Mineralogy.*

65 of filex, 16 of argill, 5 of iron, the remaining 14 gr. were dissipated.

SPECIES XIV.

Argill mixed with a notable Proportion of red Calx of Iron, and sometimes Steatites.

Red Chalk.

It hardens in fire, and then often becomes magnetic; in the strongest heat it melts into a black glass, which does not corrode the crucibles, as calcareous ores do: it affords 16 or 18 per cent. of iron; if it does not become magnetic it affords only from 7 to 14 per cent. *Rinman Historia Ferri, § 189.*

Compound Species in which the Argillaceous Genus predominates.

SPECIES I.

Compounds of the different Species of the Argillaceous Genus.

I. VARIETY.

Micaceous Marl.

II. VARIETY.

Micaceous Shistus, either Slate or Flag-stone.

III. VARIETY.

Argillaceous Genus.

99

III. VARIETY.

Micaceous Sand-stones.

IV. VARIETY.

Micaceous Horn-stone.

Green hornstone mixed with mica. *Gronstein* of *Cronsted*, § 267, frequently contains pyrites, and 20 per cent. of iron.

V. VARIETY.

Shistus and Argillaceous Grit mixed in various Proportions.

VI. VARIETY.

Shistus and Hornstone mixed in various Proportions.

SPECIES II.

Compounds of the Argillaceous and Calcareous Genus,

I. VARIETY.

Bituminous Shistus mixed with Limestone.

Marmore Nero Antico.

100 parts of this contain 18 of mild calcareous Earth, the remainder shistus, from

H 2

which

which 18 parts of oil were extracted by distillation, also argill, and magnesia, and 6 parts of iron, besides much that was not separated. 12 Roz. 63.

SPECIES III.

Compounds of the Argillaceous and Barytical Genus.

SPECIES IV.

Compounds of the Argillaceous and Muriatic Genus.

I. VARIETY.

Shistus mixed with Steatites or Soap-rock.

II. VARIETY.

Shistus mixed with Serpentine.

III. VARIETY.

Hornstone mixed with Mica and Serpentine.

IV. VARIETY.

Hornstone mixed with Mica and Steatites, or Soap-rock.

V. VARIETY.

V. VARIETY.

Mica mixed with Soap-rock, Schneidestein.

When the mica prevails the texture is flaty,

SPECIES V.

Compounds of the Argillaceous and Siliceous Genus, none of which gives Fire with Steel.

I. VARIETY.

1. *Mica mixed with Quartz, Stellstein, Cronst.*
§ 262

It is of a flaty texture and easily divided.

2. *Mica and Quartz, and a little Argill, Saxum Novaculum Linnei.*

II. VARIETY.

1. *Hornstone and Mica mixed with Quartz.*

2. *Hornstone and Shoerl.*

This is also called *Gronstein*, when the hornstone is green.

3. *Hornstone, Mica and Shoerl, Binda of the Swedes.*

It sometimes contains also quartz and pyrites.
Its specific gravity exceeds 3,000.

III. VARIETY.

White Clay mixed with Mica and Quartz, and of no particular texture. Greiss, of the Germans, or Growan of the Cornish Miners.

When the texture is lamellar and the stone harder, it is called *Gneiss*.

IV. VARIETY.

Sandstone mixed with Mica, and Felspar.

SPECIES VI.

Compounds of the Argillaceous with two or more Genera.

I. VARIETY.

Micaceous Porphyry.

This consists of a greenish grey, micaceous ground, in which red felspar and greenish soap-rock are inserted. *Saussure Voyage dans les Alpes*, p. 111, even the mica is not pure, he suspects it contains hornstone, p. 127.

II. VARIETY.

Hornstone mixed with Veins of Spar and Quartz.

Mentioned by Mr. *Saussure*, p. 120.

C H A P.

C H A P. VIII.

Siliceous Genus.

All the stones I place under this genus give fire with steel, except opals, and yellow carnelians; and none effervesce with acids, except *Lapis Lazuli* in powder, Barthoerl, martial muriatic spar, and Turkey hone.

SPECIES I.

Quartz, Crystal.

The stones of this species are in general the purest of the siliceous genus, though most contain a slight mixture of other Earths; the most obvious distinction among them, arises from their transparency or opacity.

SERIES I.

Transparent Quartz, Crystal.

This is either *colourless* and crystalized in hexagonal pyramids, and then called *mountain crystal*, or in various other forms, or amorphous. Its specific gravity is from 2,65 to 2,7; its texture lamellar and generally shattery, its appearance glassy; it cracks and loses its transparency when heated; it possesses all the other properties of pure siliceous

Earth. Mr. *Bergman* has extracted from 100 parts of mountain crystal, about 6 of argill, and 1 of calcareous Earth. 2 *Bergm.* 112. So also has Mr. *Abilgaard.* *Densk. Sbrift.* 1781. Yet Mr. *Gerhard* says, that some are so pure as to contain neither. *Gerh. Beytrage*, 78 and 85. He also says that the amorphous crystals, though colourless, being long digested in acids, afforded when treated with pure prussian alkali, some traces of iron, *Ibid.* 85.

The purest and most transparent of these crystals form the false diamond, called bristal, or kerry stone, *diamant d'Alençon*, &c.

The coloured transparent crystals derive their tinge generally from metallic particles in exceeding small proportion; they all loose their colour when heated; these form the false Gems. The most remarkable are the *red*, from *Oran*, in *Barbary*; false rubies.

Yellow. From *Bohemia*; false topazes.

Green. False emeralds and prasius.

Violet } From *Bohemia* and *Saxony*.
Blue. }

It is said that brown crystals may be cleared by boiling them in tallow. 7. *Roz.* 360.

Mr.

Mr. *Bergman* has formed perfect crystals by dissolving siliceous Earth in the sparry acid, and suffering it to crystalize slowly. It is probable that nature forms them in a long course of time from a solution or diffusion of this Earth in pure water, or water that holds a little argill or calcareous Earth which probably enable it to take up more of the siliceous Earth than it otherwise could. Perhaps the experiment which once succeeded with Mr. *Achard*, was owing to some such cause.

SERIES II.

Opake Quartz, or Pebbles.

Those are also crystalized, or amorphous, either white, grey, or yellowish, or tinged of other colours by metallic particles. The former are less pure than those of the first series, containing a larger proportion of argill, or at least the argill is less perfectly united with the siliceous part. Their specific gravity is from 2,4 to 2,7; their surface either rough, or smooth and shining, the last are called *fat quartz*; the texture either lamellar or granular; they crack like the former in fire, and become of a duller colour; when rubbed against each other they emit a phosphoric smell. They are often found in round masses in the beds of rivers.

The

The Coloured Opaque Quartz are either.

Black, being mixed with a large proportion of iron.

Red, according to *Cronsted* they contain copper, but Mr. *Bergman* could find none in them. 2 *Bergm.* 430.

Blue, from *Uto* in *Sweden*.

Green, found at *Adelsdorf* in *Sweden*,

SERIES III.

Arenaceous Quartz or Sand.

Though the powdery state of other stones does not deserve any particular notice: yet that of quartz or flint does, from the great use that is made of it, and from its seeming to possess properties which are incompatible with it in a grosser state. It is of various colours and incapable of forming a mass or hardening with water, the purest is white, the minute particles of which, when inspected through a lens are transparent. It is seldom perfectly pure; Mr. *Achard* says that the fine white sand of *Freyenwald*, which is used for the porcelain manufactories contains $\frac{1}{4}$ of its weight of argill and calcareous Earth, but this I should rather take to be a petro-flint
in

in powder. The fineness of some species of sand is so great as to pass through sieves, that contain 10,000 vacuities in the space of an inch, as Mr. *Wedgewood* one of the most celebrated manufacturers of earthen ware in Europe, has assured me. Hence this Earth has been found suspended in some waters in the quantity of 1 grain in a gallon. See 2 *Bergm.* 47, and *Cad.* in the Memoirs of the French Academy for 1767.

SPECIES II.

Siliceous Earth intimately mixed and partly combined with about $\frac{1}{4}$ of its weight of Argill, and $\frac{1}{10}$ of its weight of Calcareous Earth.

Common Flint or Pebble, Hornstein, Kiesel of the Germans.

This stone is found of all colours, or variegated with veins of different colours; it is commonly covered with an opaque white crust, which seems of the same nature, but more imperfectly combined; this crust adheres to the tongue like clay, yet strikes fire with steel, so that probably it contains a larger proportion of argill than the kernel. Flint is always semi-transparent in thin pieces; its hardness is various, though it always gives fire with steel; its texture is solid, whereas,

whereas that of quartz is shattery ; it breaks with smooth surfaces, one of which is convex, the other concave ; it is never found crystalized, but rather in separate irregular nodules, scattered through other strata, and plentifully in *England* in beds of chalk ; it has seldom any fissures, with which quartz abounds ; its specific gravity is from 2,65 to 2,700.

Flints are infusible *per se* in the strongest fire, but generally become white and brittle by reiterated calcination, which seems to indicate that they all contain a little water ; and hence also, their decrepitation, when heated ; The same may be said of quartz ; they are affected by fluxes in the same manner as the purest stones of this genus.

The common brown flint exhibited on Mr. *Wiegley's* analysis 80 per cent. of siliceous Earth, 18 of argill, and 2 of calcareous. 6 *N. Art. Natur. Curios.* p. 408. Coloured flints undoubtedly contain metallic particles.

To this species we must also annex the finer flints commonly called *Egyptian pebbles*, *hæmachates*, *stigmities*, *flex sardus*. These differ from common flints ; 1st. in this, that they are less, if at all transparent ; 2^d. that their texture is finer, harder, and closer, and
their

their specific gravity greater; 3^d that they are always covered with an ochry crust; but they break with conchoidal surfaces, as flints do. Their colour is reddish, yellow, black, brown, or grey, or beautifully variegated. They probably contain metallic particles.

SPECIES III.

Siliceous Earth intimately mixed with from $\frac{1}{4}$ to $\frac{1}{3}$ of its weight of Argill, and from $\frac{1}{15}$ to $\frac{1}{10}$ of its weight of Calcareous.

Petro-filex, Chert.

This stone differs but little from the former in external appearance, only it is duller and less transparent; it is found of all colours, but generally dark blue, or yellowish grey; it breaks with conchoidal surfaces like the former, but is generally softer; it runs in veins through rocks, and hence derives its name; its specific gravity is from 2,59 to 2,7: in fire it whitens and decrepitates like filex, but is generally more fusible, for it commonly melts *per se*: it is not totally dissolved in the dry way by mineral alkali, but borax and microcosmic salt dissolve it without effervescence.

From a reddish petro-filex used in the
Count de Lauragais Porcelain Manufactory,
and

and there called a felt-spar, I extracted 72 per cent. of filex, 22 of argill, and about 6 of mild calcareous Earth, but could not melt it by the blow-pipe. I believe the calcareous Earth was not in a mild state in the stone. It shewed no sign of iron notwithstanding its slight reddish colour, nor of any other metal.

SPECIES IV.

Siliceous Earth intimately mixed with about $\frac{1}{3}$ of its weight of Argill, and $\frac{1}{6}$ or $\frac{1}{7}$ of its weight of Calx of Iron.

Jasper, Diaspro of the Italians.

This species also borders on the former, but it has a still duller, less glassy, and more earthy appearance in its fracture, and its granular texture is more distinct; it also often breaks with conchoidal surfaces; it is capable of a fine polish; its colour is generally reddish or green, or striped; but it is also found blue, grey, or whitish; its specific gravity is from 2,68 to 2,778, or more, when it contains more iron. In fire it retains its colour much longer than petro filex, never decrepitates, but grows rather harder, as Mr. Wedgwood assured me, and does not melt *per se* in clay crucibles, though it does in those made of chalk. Alkalis borax and microcosmic salt

salt affect it like the former species. Mr. *Gerhard* says that some sorts of jasper melt *per se*: these contain an over proportion of iron, or else calcareous Earth, and then form the link betwixt cherts and jaspers.

The green jaspers contain iron in a semi-phlogisticated state, and have often been confounded with malachites, but these latter never give fire with steel, to say nothing of the entire difference of their composition. Red jaspers contain iron more dephlogisticated.

Sinople is a dark red jasper or flint, which strikes fire with steel, and affords in the dry way 10 per cent. of iron, and melts into a black slag. *Rinn. Hist. Ferri*, § 189. If tried with the Prussian alkali, it would probably shew 18 or 20 parts of iron, as this always separates nearly double the quantity of iron that can be extracted in the dry way.

Of the spontaneous Decomposition of Stones by long Exposure to the Air.

Flints, jaspers, petro-filex, felt-spar, granites, lavas and ferruginous stones, have frequently been said to be decomposed by long exposure to the air, and the observations of Mr. *Greville* and Sir *William Hamilton* have removed every doubt I entertained on this head.

With

With regard to ferruginous stones in which the calx of iron is not much dephlogistified, this decomposition is easily understood, for this calx gradually becomes more dephlogistified by the action of water and air, attracts water and fixed air, and loses its adherence with the siliceous or other stony particles: this is seen to happen to basaltes, toadstone, ferruginous limestone, &c. In other stones this decomposition may arise from their containing calcareous Earth in a caustic state, or manganese, for these will gradually attract water and fixed air, and then swell, burst and loosen the whole texture of the stone, as we see happen to bricks that contain lime. Thus also glass is decomposed by long exposure to the air, the alkali attracting water and aerial acid. Mortar, on the contrary hardens by long exposure to the air, because, though the aerial acid be attracted, yet a great part of the water exhales.

SPECIES V.

The finer Flints mixed with various Proportions of other Earths and Iron.

Precious Stones of the second Order.

I. VARIETY.

Agates,

The oriental agate is almost transparent, and of a glassy appearance, but whitish, with
inward

inward protuberances. The occidental is of various colours, and often veined with quartz or jasper; it is mostly found in small pieces covered with a crust, and often running in veins through rocks, as flints and petro-silex, to which it is analogous, but more transparent, the Earths being better combined and the grain closer; its specific gravity is 2,64; it often forms the stony matter of petrifications.

Agates that present arborisations are called mochoes.

Alkalis, borax and microcosmic salt affect this stone in the same manner as they do flints.

II. VARIETY.

Opal, Oculus Mundi, Lapis Mutabilis.

This stone is of different colours, white, yellowish, or greenish brown; its peculiar characteristic is to reflect different colours, according to the different positions of the eye; it is mostly of a spongy texture, and admits water into it, and generally too soft to strike fire with steel; its specific gravity is from 1,7 to 2,24.

The usual fluxes act on it as on flints. Mr. Bergman has extracted argill from it.

I

Pseudopal

Pseudopal is opake, and reflects green and yellow rays, and hence called cat's eye.

Avanturine resembles an opal with gold specks, but is a product of art.

III. VARIETY.

Chalcedonian.

Its colour is a bluish cloudy white, or grey, with shades of other colours, and transversely inspected presents an iris; when white and opake it is called *chachelong*: its specific gravity, according to Mr. *Bergman*, is from 2,5 to 4,36. Stones of this latter weight must be very different from those of the former. These stones sometimes contain water. It is affected by the usual fluxes, as flint.

According to the experiments of Mr. *Bergman*, the chalcedony of *Fero* contains 84 per cent. of silex and 16 of argill. Mr. *Bindheim* found another sort to contain 83,3 of silex, 11 of calcareous Earth, and 1,6 of argill, besides a minute portion of iron. 3
Schrift. Naturfor. Freunde, p. 429.

Opals and chalcedonies, which by admitting water within their pores become transparent, are called *hydropheanes*. This phenomenon

nomenon is well explained in the second volume of Mr. *Bergman's* works.

IV. VARIETY.

Onyx.

This is a very hard stone of the colour of the human nail, with straight or circular zones of another colour; if the zones themselves be of different colours, it is more esteemed, and called *camebaya*: it is almost opake; its specific gravity is from 2,5 to 2,6; it is affected by fluxes as the former varieties.

V. VARIETY.

Carnelian.

Its colour is of different shades of red; it is also of different degrees of transparency and hardness: the best is of an orange or yellow red, and gives fire with steel; the whitish or yellowish are too soft to give fire with steel, and less esteemed; its specific gravity is from 2,6 to 2,7; it loses its colour in fire. Fluxes affect it like the above.

VI. VARIETY.

Sardonyx.

It consists of chalcedony and carnelian, united either in zones, strata, or spots.

SPECIES VI.

Siliceous Earth perfectly united to, from an equal to 3 times its weight of Argill, and from $\frac{1}{8}$ to an equal weight of Calcareous Earth, together with from $\frac{1}{18}$ to an equal weight of Iron.

Precious Stones of the first Order.

I derive the denominations of these stones from their colour and hardness, and not from their hardness singly, as Jewellers mostly do, as this property, though it contributes to their splendor and value, has but little or no connexion with their composition. I also omit many sub-denominations of each sort of these stones, which are to be found in treatises expressly written on that subject. The specific gravity of all of them exceed 2,76, whereas that of coloured crystals never does. Their singular lustre and transparency are well known.

I. VARIETY.

Red.

Ruby, Oriental.

It is commonly found crystalized in an octohedral form; its texture is foliated; its
hardness

hardness much greater than that of any other stone, and yields only to that of diamond; its specific gravity from 3,18 to 4,283.

In fire it is invitrifiable *per se*, and does not yield even to the focal rays of a burning glass, but a flame excited by dephlogisticated air, directed by a blow-pipe, readily melts it; it does not lose its colour in a heat that would melt iron. Borax and microcosmic salt effect its fusion, but mineral alkali fails.

100 parts of it contain, according to Mr. *Bergman*, 40 of argillaceous, 39 of siliceous, 9 of mild calcareous Earth, and 10 of iron.

Or, according to Mr. *Achard*, 41,66 of siliceous Earth, 36,66 of argill, 8,33 of calcareous Earth, and 10,83 of iron.

Brazil rubies are paler, and said to be found in hexangular or polyangular crystals.

Jewellers, among whom hardness and transparency are the chief characteristics, mention also white and amethyst coloured rubies, but these have not been analysed.

Oriental rubies are chiefly found in *Pegu*, *Ceylon*, *Bijnagar*, and *Cambaya*. A baser sort

is found in *Finland, Bohemia, Silesia, Saxony* and *Hungary*.

II. VARIETY.

Yellow.

Topaz, Hyacinth.

Topaz is of a gold colour; its texture foliaceous; its form cubic, parallelipedal, or prismatic; its specific gravity from 3,46 to 4,56; it loses its colour only in a very strong heat, and of the usual fluxes it yields only to borax and microcosmic salt.

According to Mr. *Bergman*, 100 parts of it contain 46 of argill, 39 of siliceous Earth, 8 mild calcareous, and 6 of iron. Its great specific gravity shews these Earths to be very perfectly united.

Oriental *hyacinth* is of a reddish yellow colour, generally crystalized in a prismatic form; in a strong heat it becomes paler, and according to Mr. *Achard*, may be melted in a wind furnace in 2 hours.

According to Mr. *Bergman*, 100 parts of it contain 40 of argill, 25 of silex, 20 of mild calcareous Earth, and 13 of iron; and
according

according to Mr. *Achard*, 41,33 of argill, 21,66 of filex, 20 of calcareous Earth, and 13,33 of iron.

Hyacinths are found in *Poland, Bohemia,* and *Saxony*.

III. VARIETY.

Green.

Emerald, Chrysolite, Beryl.

The colour of emerald is pure green; it is sometimes found in round flat pieces, but mostly crystalized in hexagonal prisms; its specific gravity is from 2,78 to 3,711. It is the softest of all the precious stones.

According to Mr. *Achard*, it preserves its colour in a porcelain heat, and only becomes more opaque; in a stronger heat it melts into a slag. *Mem. Stock.* 1768. Like the foregoing it eludes the force of mineral alkali, but yields to borax and microcosmic salt. With the former, according to Mr. *Quist*, it gives a colourless glass.

100 parts of it contain, by Mr. *Bergman's* analysis, 60 of argill, 24 of filex, 8 of calcareous Earth, and 6 of iron; and by that of

Mr. *Achard*, 60 of argill, 21,66 of filex, 8,33 of calcareous Earth, and 5 of iron.

It was antiently found in *Egypt*, now chiefly in *Peru*.

Chrysolite, or *Beryl*, is of a light yellowish green; it melts *per se* into a slag; it is softer than crystal; it yields only to borax and microcosmic salt, and is scarcely affected by alkalis: when ready to melt it becomes phosphorescent.

Aqua Marine (augites) is of a bluish green; it melts *per se* by the blow-pipe.

IV. VARIETY,

Blue,

Sapphire.

Its colour is sky blue; its texture foliaceous; its form hexangular or polyangular prisms or parallelepipeds; its specific gravity from 3,78 to 3,994; the oriental preserves its colour in a porcelain heat, and will not melt *per se*, but that of *Brazil* loses its colour; it is affected by fluxes as the other varieties.

Mr. *Bergman* found 100 parts of this stone to contain 58 of argill, 35 of filex, 5 of mild

mild calcareous Earth, and 2 of iron; and Mr. *Achard* 58,33 of argill, 33,33 of filex, 6,66 of calcareous Earth, and 3,33 of iron.

Jewellers mention white, green, and yellow sapphires, or pale red.

SPECIES VII.

Amethyst.

Some of this species are as transparent as the former stones, others duller; its specific gravity, which reaches only from 2,6 to 2,7, makes me judge it to be very different from them; its colour is pale bluish red; its texture nearly granular, and generally crystallized in hexangular prisms; it loses its colour in a strong heat, but does not melt *per se*, though with borax it gives a colourless glass; its composition has not yet been examined.

SPECIES VIII.

Siliceous Earth united to $\frac{1}{5}$ of its weight of Calcareous Earth, still less of Magnesia, with an exceeding small Proportion of Iron, Copper, and Sparry Acid.

Chrysoprasium.

It is of an apple green colour, and semi-transparent; it has never been found crystallized;

stalized ; it is much harder than green fluors or green quartz.

When distilled, a little of its Earth sublimes ; it loses its transparency and colour in fire, but does not melt *per se*.

Mr. *Achard* found 100 parts of it to contain 95 of siliceous Earth, 1,7 of calcareous Earth, 1,2 of magnesia, 0,4 of iron, and 0,6 of copper.

SPECIES IX.

Siliceous Earth intimately mixed with blue martial Fluor, and a small Proportion of Gypsum.

Lapis Lazuli.

The colour of this stone is a beautiful opake blue, which varies a little in intensity, and is generally sprinkled over with yellow, bright, pyritaceous specks or streaks : it obstinately retains its colour in a strong heat, which distinguishes it from other blue stones : it is of an equable or very fine granular texture, and takes a beautiful polish ; its specific gravity is 3,054.

If powdered and not calcined, it effervesces very slightly with acids, but if calcined,

cined, it does not effervesce, but becomes gelatinous.

In a strong fire it melts *per se* into a whitish glass.

This stone has been examined by Mr. *Margraaf* only with a view of finding whether it contained copper. He found none, but only calcareous Earth, gypsum, iron, and filex. Mr. *Rinman* lately found it to contain the sparry acid.

SPECIES X.

Jade.

Jade is found in scattered masses like pebbles, semi-transparent, of a greasy look, and exceeding hard: its colour is either white, grey, olive, green, or yellowish: its specific gravity from 2,97 to 3,389. According to Mr. *Sauffure*, it is scarcely soluble in acids, at least without particular management, and also infusible in fire. However, he seems to have extracted iron from it.

May it not be a compound of filex and magnesia?

SPECIES XI.

SPECIES XI.

Siliceous Earth intimately mixed and partly united with 0,209 of its weight of Argill, 0,164 of its weight of ponderous Earth, and 0,12 of its weight of Magnesia.

Felt-spar, Spathum Pyromachum, Rhombic Quartz, Quartzum Spathosum, Spathum Durum, Petunse.

This stone, which is generally opaque, is found of all colours, white, red, yellow, brown, green, violet, or iridescent; sometimes crystalized in rhombic, cubic, or parallelipedal forms, and often amorphous: its texture close but lamellar, and breaks like spar: its specific gravity is from 2,4 to 2,6, and Mr. *Gerhard* says he found it even 3,5; but it was then probably loaded with metallic particles: it is harder than fluors, but not so hard as quartz.

It melts *per se* more quickly and perfectly than fluors, into a whitish glass, and does not, like them, attack the crucibles. Borax and microcosmic salt entirely dissolve it without effervescence, but it does not easily enter into fixed alkalis. When crystalized, it decrepitates in a moderate heat, otherwise not.

It

It never constitutes veins or strata, but is either found in loose masses at most 2 inches long, or mixed with sand or clay, or imbedded in other stones, as granites, &c.

100 parts of the white contain about 67 of siliceous Earth, 14 of argillaceous, 11 of ponderous, and 8 of magnesia.

The specific gravity of the specimen I tried was 2,542.

Labrador stone is of this species; it reflects the colours of the rainbow, is somewhat softer than common felt-spar, and is found in pretty large pieces, generally of a dark grey colour: its specific gravity is 2,755.

Felt-spar is undoubtedly the stone which the Saxons use as petunse in their porcelain manufactories. 3 *Berlin Beschäftig.* p. 471.

SPECIES XII.

Siliceous Zeolyte.

This differs from that described under the argillaceous genus only in this, that it gives fire with steel. It is white, and found at *Mæssiberg*. 3 *Bergm.* 224. It is very rare.

SPECIES XIII.

SPECIES XIII.

Siliceous Earth imperfectly united to about 0,7 of its weight of Argill, and $\frac{1}{2}$ of its weight of Calcareous Earth, without Iron.

Vesuvian Garnet.

It is improperly called a garnet, as it contains no iron, and it differs from zeolyte in containing no water, and also in texture and hardness: its colour is white, sometimes opaque and sometimes transparent, and very hard: it is difficultly acted on by any of the fluxes.

According to Mr. *Bergman*, it contains 55 per cent. of siliceous Earth, 39 of argill, and 6 of calcareous Earth.

SPECIES XIV.

Siliceous Earth more or less perfectly united to 0,63 of its weight of Argill, about 0,4 of its weight of Calcareous Earth, and from 0,28 to about 0,41 of its weight of dephlogisticated Iron.

Garnet.

When not over-loaded with iron it is transparent, though, from the intensity of its colour,

lour, which is a bluish or yellowish red, its transparency is often obscure, except it be held to a strong light: it is generally crystallized in various polygon forms, but it is frequently amorphous: its texture is granular; its specific gravity from 3,6 to 4,188.

It melts *per se*, though difficultly, into a black slag. Mineral alkali does not attack it so powerfully as borax or microcosmic salt.

It retains its colour in a strong calcining heat.

It is often found in small grains, imbedded in stones of the commonest kind.

100 parts of it contain, according to Mr. *Achard*, 48,3 of siliceous Earth, 30 of argill, 11,6 of calcareous Earth, and 10 of iron.

Opake garnets, over-loaded with iron, scarcely give fire with steel, are sometimes crystallized and sometimes amorphous, and either red, yellowish, or blackish. They afford about 20 per cent. of iron. Sometimes they contain tin and even lead, but very rarely. 2 *Bergm.* 106.

SPECIES XV.

Siliceous Earth more or less perfectly united to from 0,46 to 0,83 of its weight of Argill, from $\frac{1}{4}$ to $\frac{1}{2}$ of Calcareous Earth, and to $\frac{1}{2}$ or $\frac{1}{3}$ of semiphlogisticated Calx of Iron, and from $\frac{1}{8}$ to $\frac{1}{4}$ of Magnesia.

Schoerl.

Its distinguishing properties are, 1st. either a sparry or semi-vitrified appearance, like an enamel or a slag; 2^d. a filamentous or scaly texture, which distinguishes it from garnets; the filaments either separate from each other, or conjoined and plated; 3^d. fusibility *per se* in a moderate heat; 4th. a specific gravity from 3, to 3,6, rarely 4,000, and only when loaded with iron; 5th. its hardness nearly as that of crystal.

I. VARIETY.

Transparent.

This is always crystalized in some polygon form: its texture obscurely sparry: its colour brown, reddish brown, greenish or yellowish brown, or violet: its specific gravity from 3, to 3,6.

A

A reddish brown, prismatic shoerl of this sort, from *Vesuvius*, contained, according to Mr. *Bergman*, 48 per cent. of siliceous Earth, 40 of argill, 5 of calcareous, 1 of magnesia, and 5 of iron. The usual fluxes affect this species, as they do the foregoing.

The filamentous sort resembles asbestos, and differs externally only in transparency and breaking with an even surface.

II. VARIETY.

Opake.

These are of all colours, white, black, red, brown, greenish, and violet; the filaments are conjoined and parallel, or diverge, as from a common center. Those of a scaly or sparry appearance are generally greenish or black, and are called *Hornblende*. They are frequently crystalized in regular forms, and often so soft as to be scraped with a knife.

100 grains of the black crystalized sort from *Albano*, afforded Mr. *Bergman* 58 of filix, 27 of argill, 5 of calcareous Earth, 1 of magnesia, and 5 of iron. 3 *Bergm.* 207. Other sorts have afforded 50 per cent. of siliceous

aceous Earth, 30 of argill, 1 or 2 of magnesia, and 18 or 20 of iron.

The white fort probably contains less iron.

All these forts become reddish by calcination.

SPECIES XVI.

Siliceous Earth imperfectly united with 0,34 of its weight of Calcareous Earth, 0,107 of its weight of Argill, 0,08 of Magnesia, 0,026 of Iron, and about 0,048 of Water.

Bar Shoerl, Stangen Shoerl of the Germans.

This was lately found in the Carpathian Mountains by Mr. *Fichtel*, imbedded in limestone, and crystalized in prisms: it slightly effervesces with acids.

According to Mr. *Bindheim*, 100 parts of it contain 61,6 of siliceous Earth, 21,6 of calcareous Earth, 6,6 of argill, 5 of magnesia, 1,6 of iron, and 3 of water. 3
Schrift. Naturforsch. Freunde, p. 452.

SPECIES XVII.

SPECIES XVII.

Siliceous Earth imperfectly united with from 1,05 to 1,47 of its weight of Argill, from 0,3 to 0,4 of its weight of mild Calcareous Earth, and from 0,15 to 0,243 of its weight of Iron.

Tourmaline.

Tourmaline has hitherto been found only in *Ceylon*, *Brazil*, and the *Tyrol*. A specimen of each has had the advantage of having been particularly examined by Mr. *Bergman*. That of *Ceylon* is of a dark brown, or yellowish colour, its specific gravity 3,065, or, 3,295; that of *Brazil* is green, blue, red, or yellow, and its specific gravity 3,075 or 3,180; that of *Tyrol*, by reflected light, is of a blackish brown, but by refracted light, yellowish, or in thin pieces, green; its specific gravity 3,050; mostly crystalized in polygon prisms, but sometimes amorphous. The thickest parts are opaque: the thin more or less transparent.

All are electric when heated to about 200 of *Fahrenheit*. Their texture is lamellar, and their surface has a glassy appearance.

In fire none of them decrepitate; but those of *Ceylon* and *Tyrol* melt *per se* into a black

black frothy slag. That of *Brazil* forms only a brittle scoria. Of the usual fluxes, borax dissolves them best, microcosmic salt and mineral alkali partially.

The proportion of their constituent principles is thus exhibited by Mr *Bergman*:

Tourmaline of Tyrol.

Argill,	-	-	-	42
Silex,	-	-	-	40
Calcareous Earth,	-	-	-	12
Iron,	-	-	-	6
				100

Tourmaline of Ceylon.

Argill,	-	-	-	39
Silex,	-	-	-	37
Calcareous Earth,	-	-	-	15
Iron,	-	-	-	9
				100

Tourmaline of Brazil.

Argill,	-	-	-	50
Silex,	-	-	-	34
Calcareous Earth,	-	-	-	11
Iron,	-	-	-	5
				100

SPECIES XVIII.

SPECIES XVIII.

Siliceous Earth mixed with 0,3 of its weight of Argill, 0,17 of mild Calcareous Earth, 0,04 of Magnesia, and 0,5 of Iron.

Basaltes, Trapp of the Swedes, Saxum Danemorensfc.

A dark grey or black stone, generally invested with a ferruginous crust and crystallized in opaque triangular or polyangular columns, is called basaltes; that which is amorphous, or breaks in large, thick, square pieces, is called *trapp*. Their constituent principles, and relation to acids and fluxes, are exactly the same. The texture of this stone is either coarse, rough, and distinct, or fine and indiscernable. This latter sort is often reddish; it is always opaque, and moulders by exposure to the air; some specimens give fire with steel very difficultly, though it is always very compact; sometimes it is sprinkled over with a few minute shining particles: its specific gravity is 3,000.

When heated red hot, and quenched in water, it becomes by degrees of a reddish brown colour: it melts *per se* in a strong heat into a compact slag. Borax also dissolves it in fusion, but mineral alkali not intirely.

According to Mr. *Bergman*, 100 parts of the basaltcs contain 52 of siliceous Earth, 15 of argill, 8 of calcareous, 2 of magnesia, and 25 of iron. 3 *Bergm.* 213. And with this Mr. *Meyer* very nearly agrees, 14 *Naturforsch.* 5.

SPECIES XIX.

Siliceous Earth mixed with 0,69 of its weight of Argill, and 0,41 of its weight of Iron in a semiphotogenicated state.

Rowly Ragg.

This stone is also of a dusky or dark grey colour, with numerous minute shining crystals; its texture granular; by exposure to the air it acquires an ochry crust; its specific gravity 2,748.

Heated in an open fire it becomes magnetic. In a strong heat it melts *per se*, but more difficultly than basaltcs.

According to Dr. *Withering's* analysis, 100 parts of it contain 47,5 of siliceous Earth, 32,5 of argill, and 20 of iron.

SPECIES XX.

SPECIES XX.

Siliceous Earth more or less perfectly united to from $\frac{1}{3}$ to $\frac{2}{10}$ of its weight of Argill, 0.3 or 0.4 of its weight of Iron, and a small proportion of pure Calcareous Earth, but this is sometimes wanting.

Lava.

By *Lava* I understand the immediate product of liquefaction or vitrification by volcanic fire, which should carefully be distinguished from the subsequent productions affected by the water either in a liquid or fluid state, which generally is ejected at the same time.

All lavas are more or less magnetic, give fire with steel, are of a granular texture, and fusible *per se*. Most are decomposable by long exposure to the air, sooner or later, according to the proportion of iron and calcareous Earth, and according as they were more or less perfectly melted or vitrified.

Mr. *Bergman*, in his elaborate treatise on volcanic products, distinguishes three varieties of lava; the cellular or frothy, the compact, and the vitreous.

I. VARIETY.*Cellular Lavas.*

These underwent only the first and lowest degree of fusion, being just mollified and heated sufficiently to expell the fixed air contained in the argillaceous particles; hence they abound in small cavities arising from the expansion of that air after it had recovered its elastic state. Their specific gravity is various: some are so light, by reason of their internal cavities, as to float for some time on water, and hence, have been mistaken for pumice stones, but they differ from these in this, that their texture is never filamentous.

Their colour is black, grey, brown, or reddish brown, and their cavities are often filled with crystalizations.

Of this sort is the black cellular mill-stone of the *Rhine*.

These stones contain from 45 to 50 per cent. of silex, and from 15 to 20 per cent. of iron, 4 or 5 per cent. of pure calcareous Earth, and the remainder argill.

II. VARIETY.

II. VARIETY.

Compact Lavas.

These have undergone the 2d or more perfect degree of fusion, yet they are not entirely destitute of cavities which contain finer crystals, or pieces more perfectly vitrified; their colour is black or brown; their fracture is still obscure, and not glassy, as the stones themselves are opaque: if not cracked, they give a clear sound when struck.

The proportion and quality of their constituent parts are the same as in the foregoing variety. The usual fluxes attack them with difficulty, and microcosmic salt has scarce any power over them.

III. VARIETY.

Vitreous Lavas.

These have been more completely melted, and form vitrifications of different colours, generally black or ash-coloured, rarely blue or greenish.

A specimen of this glass, examined by Mr. *Bergman*, afforded 49 per cent. of silica,

35 of argill, 4 of pure calcareous Earth, and 12 of iron. Another specimen from the *Lipari Islands* afforded 69 of flix, 22 of argill, and 9 of iron. This must have been exposed to a very strong heat, for they melt very difficultly *per se*.

The *black Agate of Iceland*, (*Lapis obsidianus*, *Piedra de Galinaço*) is of this sort, and its principles and their proportions nearly the same.

The harder sort of pitch stones, already described, which give fire with steel, belong to this species.

Mr. *Saussure* has ingeniously imitated all these species of lava, by melting more or less perfectly the compound argillaceous species into which hornstone enters as the most copious ingredient, and which he therefore calls *Hornrock*, *Roche de corne*, and which are already described. *Voyage dans les Alpes*, p. 127. And hence he justly conjectures that this stone, marl, and the schisti (Species 6, 7, and 8 of the Argillaceous Genus) are the principal materials of lava. *Ibid*, 131, 132.

SPECIES XXI.

SPECIES XXI.

Siliceous Earth mixed with 0,11 or 0,17 of its weight of Magnesia, and a little of Calcareous Earth.

Pumice-stone, Pierre Ponce, Bimstein.

This seems rather a volcanic ejection than a volcanic product; its colour is grey, white, reddish brown, or black: it is hard, rough, and porous, and consists of slender fibres parallel to each other; very light, for it swims on water, and difficultly gives fire with steel. It seems to have originally been an asbestos decomposed by the action of fire.

100 parts of it contain, according to Mr. Bergman, from 6 to 15 of magnesia, with a very small proportion of calcareous Earth, the remainder filix.

SPECIES XXII.

Siliceous Earth mixed with less than its own weight of Magnesia and Iron.

Martial Muriatic Spar.

Mr. Monnet, a Mineralogist of considerable note, lately discovered this stone at *St. Marie aux Mines*, and called it *pisolithes*; but as a
very

very different compound is generally denoted by this name, I have called it martial muriatic spar, a name which agrees better with its properties.

It is of a hard, solid, and sparry texture ; of a grey, ochry, dull colour, but internally bright : it gives fire with steel, yet effervesces with acids.

In a strong heat it grows brown, but at last melts *per se*.

100 parts of it contain 50 of silex, the remainder mild magnesia and iron, but in what proportion is not mentioned. 13 *Roz. Suppl.* 416.

SPECIES XXIII.

Siliceous Earth intimately mixed with $\frac{2}{3}$ of its weight of mild Calcareous Earth.

Turky Stone, Cos Turcica.

This is of a dull white colour, and uneven texture ; some parts appearing more compact than others, so that it is in some measure shattery : it hardens with oil ; its specific gravity is 2,598 ; it gives fire with steel, yet effervesces with acids.

Siliceous Genus.

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I found 100 parts of it to contain 25 of mild calcareous Earth, and no iron. There probably are two sorts of stone known by this name, as Mr. *Wallerius* affirms that which he describes, neither to give fire with steel, nor effervesce with acids.

SPECIES XXIV.

Siliceous Earth mixed with mild Calcareous Earth and Iron.

Ragg-stone.

Its colour is grey; its texture obscurely laminar, but the laminæ consist of a congeries of grains of a quartz appearance, coarse and rough; its specific gravity is 2,729; it effervesces with acids, and gives fire with steel. I found it to contain a portion of calcareous Earth, and a small proportion of iron. It is used as a whetstone.

SPECIES XXV.

Arenaceous Quartz consolidated by a smaller proportion of Calcareous Earth, or Argill, and still a smaller of Iron.

Siliceous Grit, Sandstone, Freestone, Cos Arenarius, Grais.

Under this species I comprehend only such as strike fire with steel, and when pounded,

pounded, form a sand rather than a powder.

I. VARIETY.

Grit with a Calcareous Cement, Quadrum.

A stone of this sort hath been already described under the calcareous genus. When it contains about 50 per cent. or more of filex it belongs to this species; it commonly contains also a small proportion of argill and iron; it hardens by exposure to the air, and then strikes fire with steel, and effervesces slightly with acids: it is sometimes crystalized in rhomboids, as at *Fontainbleau*. 100 parts of this contain, by the experiments of Mr. *Lassone*, 62,5 of filex and 37,5 of mild calcareous Earth. *Mem. Par.* 1777, p. 43.

The *Saxum margariticum* of *Linneus* belongs also to this species: it consists of quartz in a calcareous cement.

II. VARIETY.

With an Argillaceous Cement.

These do not effervesce with acids, but they strike fire with steel, though some sorts are too soft to do so until exposed for some time to the air. The free-stone from *Keredga*, near *Macclesfield*, which is of a close grain, is of this species. Its specific gravity is 2,544.

So

So also that of *Brownedge*, in *Staffordshire*, which is so perfect a sand-stone that its specific gravity is only 2,397; and the whitish grey freestone from *Uttoxeter*. All these contain a little of iron.

Stones of this species are used for whetting tools, and for filtering water, and in some countries as flates. The principal distinction among them arises from the fineness or coarseness of their grain and texture. Their colours are various, receiving different tinges from iron.

SPECIES XXVI.

Siliceous Sand consolidated by semiplogisticated Calx of Iron.

This stone does not fall into sand when powdered, and in this respect differs from the foregoing. It is generally of a brown or black colour, but grows reddish or yellowish, and moulders by exposure to the air; its specific gravity is from 2,8 to 3,6; it gives fire with steel, and does not effervesce with acids, unless it contains testaceous particles, as it frequently does: it is even often covered with shells.

The agglutinating power of solutions of iron has been shewn in an ingenious paper in the

the Philosophical Transactions for 1779, p. 35, by Mr. *Edward King*, who found a stony concretion of this sort round iron, which had been long buried in the sea.

Mr. *Gadd*, in the Swedish Memoirs for 1770, relates, that Mr. *Rinman* had found a similar concretion round an old anchor that had long been deposited in the sea. He also adds, from his own experiments, that dephlogisticated calces of iron, and particularly solutions made by the mineral acids, have not the same binding power, but, on the contrary, make loose concretions, as Dr. *Higgins* has also shewn in a late very useful treatise on cements.

To this species may be added the *black, heavy, glossy Quartz* of *Cronsted*, § 53, which he says is found in the mine of *Staf*, in *Sudermanland*, and contains a large proportion of iron.

Compound Species in which the Siliceous Genus predominates.

SPECIES I.

Compounds of the different Species of the Siliceous Genus with each other.

I VARIETY.

I. VARIETY.

Quartz and Shoerl.

This stone consists of distinct grains of each compacted together in various proportions. The quartz is generally white, or reddish; the shoerl, black, brown, white, or green: by some it is called a *granite*. Some of the paving-stones of *London* are of this sort.

II. VARIETY.

Quartz and Felt-spar.

The quartz is generally white; the felt-spar red, yellow, or brown: found in the *Alps* by Mr. *Saussure*, from whose excellent work many of the following descriptions are taken. Mill-stones and whet-stones are often of this sort.

III. VARIETY.

Jade and Shoerl.

The shoerl is interpersed through the jade; in a strong fire it melts, but the jade only whitens. *Saussure Voyage dans les Alpes*, p. 84. Its specific gravity is from 3,318 to 3,389. The jade is yellowish, the shoerl green or black.

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IV. VARIETY.

IV. VARIETY.

Jade, Shoerl, and Garnet.

Of considerable hardness and weight, with large spots of red, green, and yellow; the garnet red, the shoerl green, and the jade yellow. *Saussure*, p. 107.

V. VARIETY.

*Quartz, Felt-spar, and Shoerl,
Granite.*

These are so well adapted to each other, that, as Mr. *Saussure* well remarks, they could not have been so compacted by an accidental mixture of masses previously formed, but must have crystalized together. It may be seen among the paving stones of *London*. The quartz is white, the shoerl black or violet, and the felt-spar reddish.

VI. VARIETY.

Puddingstone, Breccias.

Stones which consist of a siliceous ground or cement, (commonly petro-filix, jasper, or siliceous grit) in which pebbles of filix or agate are interspersed; if these be round or oval, are called *puddingstones*; if angular, *breccias*. Of the coarser sorts mill-stones are often made. *Mem. Par.* 1758.

VII. VARIETY.

VII. VARIETY.

Coral Stone.

This is an aggregate of onyx, sardonx, rnelian amethyst, and quartz.

SPECIES II.

Compounds of the Siliceous with the Calcareous Species.

I. VARIETY.

Quartz and Spar.

Distinct grains of each compacted together ; the quartz generally white and semi-transparent ; the spar of a brownish yellow. *Saussure*, 104.

SPECIES III.

Compounds of the Siliceous and Barytic Species.

SPECIES IV.

Compound of the Siliceous and Muriatic Species.

I. VARIETY.

Quartz, Felt-spar, and Serpentine.

II. VARIETY.

Shoerl and Soap-rock.

Compacted of distinct masses of each, *Saussure* 104. The soap-rock is green, and

the shoerl black. It gives fire with steel, when the shoerl is struck.

III. VARIETY.

Quartz and Steatites.

Observed also by Mr. *Saussure*, the quartz white, and the steatites green.

IV. VARIETY.

Quartz, Shoerl, and Steatites.

The steatites inclosed in the quartz in the form of black kernels.

SPECIES V.

Compounds of the Siliceous, and Argillaceous Species.

I. VARIETY.

Quartz and Mica. Stellten of the Swedes. Granitello.

It strikes fire with steel, and does not easily melt; and hence used for furnaces, &c. When the mica abounds it is of a lamellar texture, its colour is generally grey, or green; the mixture of mica prevents the flex or quartz

quartz from cracking or splitting; and hence its infusibility and use in furnaces.

II. VARIETY.

*Feltspar and Mica,
Granitone.*

This stone is mentioned by *Ferber*, in his letters from *Italy*, p, 118. A stone of this sort which moulders by exposures to the air, is found in *Finland*, and is said to contain sometimes saltpetre, and sometimes common salt, it is there called *Rapakivi*, 1 Linné von Gmelin, 621.

III. VARIETY.

Quartz and Horn-stone.

In small distinct grains compacted together, this is found plentifully in the mountain of *Penmaumaure* in *Wales*. It exhales an earthy smell, gives fire with steel, and is of a thick lamellar texture: its specific gravity is 2,811. the quartz is white, and the horn-stone black, which gives the stone a bluish appearance.

IV. VARIETY.

*Quartz, Feltspar, and Mica, or Quartz, Shoerl
and Mica.*

Granite, Moor-stone.

This stone consists of distinct masses of each, firmly compacted together, their pro-

portion and size are extremely variable, as well as their colour. The three first constitute the hardest sort of the granite, and most anciently known; that into which the shoerl enters, is more subject to decomposition; it never has any particular texture, but consists of enormous shapeless masses, of great hardness.

In the finer granites, the quartz is transparent, in others generally white or grey, violet or brown; the felspar, white, yellow, red, green, or black, it is generally the most copious ingredient. The mica is also grey, brown, yellow, green, red, violet or black, and is commonly least copious. The shoerl is generally black, and abounds in the granites that contain it. Hence the colour of granites chiefly depends of the felspar or shoerl. The *red* granites consist commonly of white quartz, red felspar, and grey mica. The *grey* of white quartz, grey or violet felspar, and black mica. The *black* commonly contain shoerl, instead of felspar. The *green* commonly contain greenish quartz.

If granite be exposed to a blow-pipe, its different concretions separate from each other. In a crucible, Mr. *Gerhard* found the felspar melted into a transparent glass; under it the mica lay in the form of a black slagg, and the

the quartz remained unaltered; but when all three are powdered and mixed, it melts somewhat better, yet still the quartz may be distinguished by the help of a lens. *Gerh. Gesch.* § 51. This well explains why small white grains are frequently found in lavas. Mr. *D'Arcet's* experiments coincide with this, and also those of Mr. *Saussure*, p. 124.

V. VARIETY.

Quartz, Felspar, Shoerl and Mica.

This is also a sort of granite observed by Mr. *Saussure* in the Alps.

VI. VARIETY.

Jade, Shoerl, and Mica.

A sort of granite observed by Mr. *Saussure*.

VII. VARIETY.

Quartz, Garnet, and Mica, Norka, Murkstein.

This is either grey or reddish, and used for mill-stones, the mica is soon wore off.

VIII. VARIETY.

Porphyry.

Under this name I comprehend with Mr. *Saussure*, all those stones which in a compact

siliceous ground (generally jasper, chert, shoerl, or lava) contain either felspar, quartz, shoerl, mica, serpentine, or other species of stone in a *crystalline* form. When its ground is jasper it is hard. It is commonly either red, purple, grey, green, or black, according to the ground. The *red* commonly contains felspar in small white dots or specks, and often together with these black spots of shoerl. The *green* is either a jasper or shoerl, with spots of quartz or shoerl. Sometimes a porphyry of one colour contains a fragment of a porphyry of another colour; the green are often magnetic. Those that have chert for their ground, are fusible *per se*.

SPECIES VI.

Compounds of the Siliceous, and various Genera.

I. VARIETY.

1. *Quartz, Mica, and Serpentine.*
2. *Quartz, Mica, and Steatites.*
3. *Quartz, Mica, and Shoerl, together with Serpentine or Steatites, or Soap-rock.*
4. *Quartz, Felt-spar, Mica, and Serpentine.*

All

All these stones are called *Gneiss*, and are generally of a lamellar texture.

II. VARIETY.

Amygdaloides, Mandelstein of some.

This consists of a chert or jasper ground, in which fragments of calcareous spar, and serpentine, of an oval form, are contained.

III. VARIETY.

Variolite.

This is said to be a compound of all sorts of stones, included in a ground of serpentine. *Ferber. Italy, p. 120.*

IV. VARIETY.

Metallic Stone of Linnaeus and Born.

It consists of Quartz, clay, and steatites, and is of different degrees of hardness, sometimes the steatites is wanting, sometimes felspar is found in it.

V. VARIETY.

Quartz, Spar, and Mica. Saxum Angermannicum of Linnaeus.

C H A P. IX.

Of Vegetable and Animal Earths.

Vegetable Earth has been thought by many to be of a peculiar nature, specifically different from every other; but late experiments have fully shewn.

1st. That vegetables contain but a very small proportion of Earth of any sort, and that far the greater part of their substance consists of water, fixed air, and inflammable air in a concrete state, as remote principles, a small proportion of fixed alkali which probably is neutralized by vegetable acids, and a few other neutral salts. Thus according to the latest experiments, 33 pound of oak afford only 3 drachms of ashes. *Memoirs of Stockholm*, 1781.

2^{dly}. That the Earth of vegetables is for the greater part, either calcareous, or a mixture of all sorts of Earths, and sometimes of the calces of iron and manganese, in various proportions, according to the species of the vegetable. Thus Mr. *Bergman* found the ashes of some vegetables to contain calcareous, ponderous, muriatic, argillaceous, and even siliceous Earth; and hence ashes effervesce with acids, and are fusible *per se*, even after perfect

Vegetable and Animal Earths. 155

perfect lixiviation. He also found sometimes animal Earth, (that is phosphoric selenite,) in ashes. The Earth remaining after the putrefaction of vegetables, is exactly of the same nature. *Scheffer*, § 172. Mr. *Morveau* found the ashes of some vegetables to contain 97,5 per cent. of calcareous Earth, the remainder magnesia. Mr. *Berniard*, Mr. *D'Arcet*, and Mr. *Achard*, have had nearly the same results. 19 *Roz.* 52.

The neutral salts most usually found in ashes, are tartar vitriolate, glauher's salt, common salt, digestive salt, and selenite, also hepar sulphuris; according to *Model* a pound of rhubarb contains an ounce and a half of selenite.

Hence we see why clay is so unfavourable to vegetation, and how calcareous Earth is introduced into the bodies of animals.

Animal Earth, is obtained either from the shells of fish, or from those of eggs, or from pearls, or from the bones, horns, claws of land animals, or from the skins of insects.

That obtained from the shells of fish and from those of eggs, is found by repeated experiments to be purely calcareous; only oyster shells discover some feeble vestiges of selenite. *Bergm.* on *Scheffer*, § 173, that obtained
from

from bones, horns, claws, teeth, &c. was found by Mr. *Gahn*, to be a calcareous Earth united to the phosphoric acid; hence the solution of bones in the mineral acids can never be neutralized, a circumstance which puzzled all preceeding chymists, but which is now perfectly understood, as such solution is in fact only the solution of a neutral salt if the bones be dissolved in the nitrous or marine acids, or a decomposition of a neutral salt, if the vitriolic acid be used as a solvent; in either case a free unsaturated acid must be found. However some bones contain an excess of phosphoric acid, and some an excess of Earth, as ivory, whence some have imagined this latter to contain a peculiar Earth. Some late and accurate experiments relating to the proportion of phosphoric acid in bones by Mr. *Berniard*, may be seen in *Rozier's* journal, for 1781, p. 280, 1782, p. 43.

The phosphoric acid is separated from this Earth by calcining the bones to whiteness then dissolving them in nitrous acid, and precipitating the calcareous Earth by the concentrated acid of vitriol. A selenite is thus obtained (decomposable either by calcination with charcoal, or by boiling in a solution of mild fixed alkali,) and the phosphoric acid remains in the liquor.

APPENDIX

A P P E N D I X I.

Of Diamond and Plumbago.

These substances cannot well be arranged under any of the classes of minerals; not under that of Earths as they contain no Earth, nor under that of inflammables, as their inflammability commences in such high degrees of heat, and is so gradual that it can scarcely be remarked but by its effect in diminishing the weight of these substances after a long exposure to fire; so that they differ intirely from all other inflammables, whence I think it convenient to treat of them a part.

Diamond.

Diamond is always transparent, and mostly colourless, but sometimes tinged, yellow, reddish, green, blue, or brown; it is sometimes externally, but always internally bright; it is generally crystalized in octohedral crystals, but sometimes found in round masses: its texture is lamellar.

It strikes fire with steel, cuts the hardest crystals, and even rubies, being the hardest of all bodies: its specific gravity is from 3,5 to 3,66.

No acid has any effect on it, except the vitriolic; If diamond powder be triturated with this acid, and evaporated nearly to dryness, the acid grows black and deposits pellicles, which burn and are almost entirely consumed.

In a heat somewhat greater than that in which silver melts, diamond is intirely volatilized and consumed; it even produces a flight flame and diminishes common air, just as phlogistic substances do, and leaves a foot, so that the extraordinary conjecture of Sir *Isaac Newton*, of its being an inflammable substance coagulated is fully confirmed. Of the usual fluxes, only borax and microcosmic salt have any effect on it.

It is found in *Golconda, Visapour, Bengal*, the island of *Borneo*, and *Brazil*.

The nature of cubic diamonds has not yet been examined.

Plumbago, Reifsbley, of the German's, Blyertz, of the Swedes.

This substance is externally black, but bluish white and shining like a metal when fresh cut: its texture is micaceous and scaly, yet granular. It is used for pencils.

It

Of Plumbago.

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It is too soft to strike fire with steel: its specific gravity is from 1,987, to 2,267.

It is insoluble in the mineral acids.

In a strong heat and open fire it is wholly volatile, leaving only a little iron, which seems to be only accidentally found in it, and a few grains of silica.

The usual fluxes do not effect its fusion.

It is decomposed by detonation with nitre, in a red hot crucible.

According to Mr. *Scheele*, who first discovered the nature of this mineral, 1 part plumbago requires 10 of nitre to decompose it, whereas 1 part charcoal requires but 5 of nitre: hence it contains twice as much phlogiston as charcoal does. By receiving the air arising from its decomposition in a bladder, he found $\frac{1}{3}$ of that air to be absorbable by lime water, and consequently to be fixed air, and in the remainder a candle would burn: but as nitre itself might afford fixed air by combustion, to get rid of all objections, he decomposed plumbago by subliming and reducing the arsenical acid, after mixing it with plumbago; and thus also he obtained fixed air. It is probable that 100 grains of it contain

tain 33 of aerial acid, and 67 of phlogiston; for 100 grains of nitre contain about 33 of real nitrous acid. This is decomposed when it receives as much acid as is necessary to convert it into nitrous air, or a little more. Now 33 grains of nitrous acid are converted into nitrous air by about 6,7 grains of phlogiston: then 1000 grains of nitre require for their decomposition 67 of phlogiston: and since 100 grains of plumbago decompose 1000 of nitre, they must contain 67 of phlogiston.

A P P E N D I X II.

Of the general Examination and Analysis of Earths and Stones.

SECTION I.

Of the Examination of Earths.

When Earths are well dried and separated from every visible heterogeneity, a portion of them should be weighed and distilled in a glass retort, until the bottom begins to grow red hot. In some cases it may be proper to receive the air that arises, in a pneumatic apparatus; in all it will be proper to examine what distills over, or sublimes, whether it be acid or alkaline, with paper tinged blue by litmus, and partly reddened by distilled vinegar: if the
blue

blue be reddened, an acid exists in the distilled liquid; if the red be effaced, and the blue restored, a volatile alkali is the cause of it: if the liquor precipitates lime water, but does not precipitate nitrous selenite, then it contains fixed air: if it precipitates also nitrous selenite, it contains the vitriolic acid: if it contains the marine acid, it will not precipitate nitrous selenite, but it will the nitrous solution of silver: The loss of weight of the residuum in the retort, and the weight of the water in the receiver, will shew the proportion of the volatile ingredients.

Another portion should be digested in about 6 or 8 times its weight of pure water, and the properties of that water examined, to find whether the Earth contains neutral salts. Here the method given by Mr. *Bergman* in his analysis of mineral waters, should be followed.

SECTION II.

Of the general Examination of Stones.

Their specific gravity should first be examined; also their hardness; whether they will strike fire with steel, or can be scratched by the nail, or only by crystal or stones of still greater hardness; also their texture, pervious-

M

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ness to light, and whether they be manifestly homogenous or compound species, &c.

2^d. In some cases one should try whether they imbibe water, or whether water can extract any thing from them by ebullition or digestion.

3^d. Whether they are soluble in, or effervesce with acids, before or after pulverization; or whether decomposable by boiling in oil of tartar, &c. as gypsums and ponderous spars are.

4th. Whether they detonate with nitre.

5th. Whether they yield the sparry acid by distillation with oil of vitriol, or a volatile alkali, by distilling them with salt of tartar.

6th. Whether they are fusible *per se* with a blow-pipe, and how they are affected by mineral alkali, borax, and microcosmic salt; and whether they decrepitate, when gradually heated.

7th. Stones that melt *per se* with the blow-pipe are certainly compound, and contain at least 3 species of Earth, of which the calcareous is probably one; and if they give fire with steel, the siliceous is probably another.

SECTION III.

SECTION III.

Of the Analysis of Earths and Stones.

The best general solvent for Stones or Earths seems to me to be *Aqua Regia*, composed of two parts nitrous, and one of marine acid : if the stone or Earth effervesces strongly with acids, no other preparation is requisite than a separation of such parts as are visibly heterogenous, and pulverization ; the solution is then easily performed in a digesting heat, if requisite. The undissolved residuum, if purely siliceous, will melt into a transparent glass with about $\frac{1}{2}$ its weight of mineral alkali ; if not, it is still compounded, and its soluble parts will yield to a reiterated digestion.

If the stone does not effervesce, or easily dissolve in acids, after pulverization and digestion, but leaves an insoluble residuum evidently compound, or but slightly altered, it will require to be pulverized and mixed with twice or thrice its weight of mineral alkali, and to be exposed to a low red heat for one or two hours. I found mica to require a mixture of 4 times its weight of mineral alkali ; after which it is to be separated from the alkali by lixiviation and filtration, washing it with distilled water until the

water is absolutely tasteless and precipitates no metallic solution.

The powdered stone, thus edulcorated, is to be dried by heating it to redness, and then weighed, and 100 grains taken for subsequent experiments : it were better if still more were used, but the analysis would be more expensive.

The powder is next to be digested in 8 or 10 times its weight of *aqua regia*, in a boiling heat in a retort to which a receiver is luted, and the digestion reiterated as long as any thing appears to be dissolved by fresh portions of the acid. I found mica to require 50 times its weight of *aqua regia* before it was entirely decomposed, as the acid is so volatile as very soon to distill over. Oil of vitriol has the advantage of bearing a greater heat, dissolving baroselenite, and of acting more powerfully on argill than *aqua regia* ; but a large retort must be used, for, often towards the end it puffs and throws up the Earth or stone, and carries it into the receiver ; and it does not sufficiently act on calces of iron, if these be much dephlogisticated. Spirit of nitre affects them still less : hence I often use oil of vitriol first, then precipitate by a mild alkali what it has dissolved, and redissolve the precipitate in *aqua regia*. A perfect solution

tion being thus effected, the residuum is to be well washed, and the washings added to the solution: the residuum, well dried and weighed, gives the weight of siliceous Earth in the compound.

The solution is next to be examined; which I will suppose to contain the 4 soluble Earths, calcareous, ponderous, magnesia, and argill, and also a calx of iron: it always contains an excess of acid, of which it is in great measure deprived by boiling for a considerable time, as both acids are very volatile, and indeed, of the marine none remains but what is combined with the calx of iron, as the nitrous chafes it from the Earths. By getting rid of this excess of acid, less alkali will be required for the succeeding precipitation, and less aerial acid set loose which would retain much of the precipitate by re-dissolving it: the solution should then be evaporated to about $\frac{1}{2}$ a pint.

The solution being thus prepared, it is usual to precipitate the calx of iron from it by the Prussian alkali; but to this method I have two objections; 1st that the ponderous Earth, if any, would also be precipitated and confounded in the Prussian blue; and 2^d that this precipitation, besides being exceeding slow, seldom fails of leaving some iron still

in the solution, as the excess of the Prussian alkali, which must necessarily be added, to be certain that all the iron is precipitated, never fails to re-dissolve a portion of the Prussian blue which thus remains in the liquor, and cannot be got rid off. Hence the method I use is as follows: first, I prepare the Prussian alkali after the manner of Mr. *Bergman*, by digesting and boiling a pure alkaline solution over Prussian blue, until the alkali no longer effervesces with acids, nor precipitates a solution of nitrous selenite, or any other Earth, except the barytes: I even make it a little stronger; for if it be barely saturated with the tinging matter, it soon spoils and precipitates other Earths, the tinging matter evaporating. I next examine how much of this alkali is necessary to precipitate 1 gr. of iron from its solution in dilute vitriolic or marine acid, and I mark this on the label of the bottle that contains the alkali. I now come to the application.

The solution of the earths being weighed I take 100 grains of it, and on these I gradually pour the Prussian alkali (a portion of which is also previously weighed) until all the iron, or ponderous Earth and iron, is precipitated; the weight of the alkali used, gives that of the iron contained in 100 grains of the solution, and the quantity contained in

100 gr. of the solution, gives that contained in the whole solution, by the rule of proportion, from which the ponderous Earth, if any be found in subsequent experiments, is to be deducted.

The quantity of iron being thus found, the remainder of the solution is to be precipitated by aerated mineral alkali, and then boiled for half an hour to expel as much as possible of the fixed air; by this means the whole of its contents are precipitated, and nothing remains in solution, but cubic nitre and a little common salt; when the precipitate has settled after one or two days rest, the liquor is to be poured off, and the last portions taken up with a glass syringe. Distilled water is then to be added to the precipitate and boiled over it, and afterwards poured off and taken up until it comes off tasteless.

The precipitate being sufficiently dried, is to be re-dissolved in nitrous acid twice, and evaporated to dryness, then calcined for one hour in a white heat, and lastly treated with about six or eight times its weight of distilled vinegar, in a heat of about 60 degrees, for one or two hours; by this means the ponderous, calcareous, and magnesia Earths will be extracted and separated from

the argill and calx of iron, which will remain undissolved.

Of this acetous solution 100 grains should be taken and examined with the Prussian alkali, if any part be precipitated it is ponderous Earth, and by heating this to redness its weight may be known, or still better by a previous experiment, determining the quantity requisite to precipitate 1 gr. of acetous baroselenites, and by the rule of proportion, the quantity of it in the whole solution may be found.

The remainder of the acetous solution, is to be evaporated to dryness, and heated white in a clean polished iron crucible for two hours, then weighed and thrown into hot distilled water, the calcareous Earth, (if any,) will be dissolved in a sufficient quantity of this water, of which an ounce can scarcely dissolve 1 gr. so that frequent affusions of hot water may be requisite; the magnesia will remain undissolved, and is to be dried and weighed, its weight gives that of the pure calcareous Earth, from which that of the ponderous (if any) is to be deducted; the lime-water may also be precipitated by an aerated alkali.

Lastly, the argill and calx of iron, which remained undissolved by the acetous acid,
are

are to be heated slightly, to prevent their cohering and reiteratedly boiled in dephlogisticated nitrous acid to dryness, and finally dissolved in that acid, which will then take up only the argill, which may be precipitated, dried and weighed; though indeed this troublesome operation may be unnecessary, as the weight of the martial part being known by the experiment, with the Prussian alkali; that of the argill is known of course, when only the two remain. This is even better, as the calx always increases in weight by these operations.

Besides this general method some others may be used in particular cases.

Thus to discover a small proportion of argill, or magnesia, in a solution of a large quantity of calcareous Earth, caustic volatile alkali may be applied, which will precipitate the argill or magnesia, if any be, but not the calcareous Earth. Distilled vinegar applied to the precipitate, will discover whether it be argill or magnesia.

2^{dly}. A minute portion of calcareous or ponderous Earth, in a solution of argill or magnesia, may be discovered by the vitriolic acid, which precipitates the calcareous and ponderous, the solution should be dilute else the argill
also

also would be precipitated. If there be not an excess of acid, the saccharine acid is still a nicer test of calcareous Earth. 100 gr. of gypsum contains about 32 of calcareous Earth. 100 gr. of baroselenite contains 84 of ponderous Earth. 100 gr. of saccharine selenite contains 45 of calcareous Earth: the insolubility of baroselenite in 500 times its weight of boiling water sufficiently distinguishes it. From these *data* the quantities are easily investigated.

3^{dly}. *A minute proportion of argill in a large quantity of magnesia*, may be discovered either by precipitating the whole and treating it with distilled vinegar, or by heating the solution nearly to ebullition, and adding more aerated magnesia untill the solution is perfectly neutral, which it never is when argill is contained in it, as this requires an excess of acid, to keep it in solution. By this means the argill is precipitated in the state of embryo alum which contains about $\frac{1}{2}$ its weight of argill, (or for greater exactness it may be decomposed by boiling it in volatil alkali.) After the precipitation the solution should be largely diluted, as the Epsom salt, which remained in solution while hot, would precipitate when cold and mix with the embryo alum.

4^{thly}. A minute portion of magnesia in a large quantity of argill is best separated by precipitating the whole and treating the precipitate with distilled vinegar.

Lastly, *Calcareous Earth and Barytes* are separated either by precipitating the barytes by the Prussian alkali, or the calcareous by a caustic fixed alkali, or by precipitating both with the vitriolic acid, and evaporating the solution to a small compass, pouring off the liquor and treating the dried precipitate with 500 times its weight of boiling water; what remains undissolved is baroselenite.

Table of the comparative hardness of different Species of Stones, extracted chiefly from the Memoirs of Stockholm, for 1768.

Mr. *Quist*, the author of this Memoir determined the hardness of most of the following stones, by observing the order in which they were able to cut and make an impression on each other. The first are able to cut or scratch the succeeding, but not *vice versa*. He added also the specific gravity of the specimens he used; the first column shews the hardness; the second, the specific gravity. The four last species I have added from my own observation.

Diamond

Diamond from <i>Ormos</i> ,	-	20	
Pink Diamond,	-	19	- 3,4
Bluish Diamond,	-	19	- 3,3
Yellowish Diamond,	-	19	- 3,3
Cubic Diamond,	-	18	- 3,2
Ruby,	-	17	- 4,2
Pale Ruby from <i>Brazil</i> ,	-	16	- 3,5
Spinel,	-	13	- 3,4
Deep blue Sapphire,	-	16	- 3,8
Ditto paler,	-	17	- 3,8
Topaz,	-	15	- 4,2
Whitish ditto,	-	14	- 3,5
Bohemian,	-	11	- 2,8
Emerald,	-	12	- 2,8
Garnet,	-	12	- 4,4
Agate,	-	12	- 2,6
Onyx,	-	12	- 2,6
Sardonyx,	-	12	- 2,6
Amethyst,	-	11	- 2,7
Crystal,	-	11	- 2,6
Carnelian,	-	11	- 2,7
Green Jasper,	-	11	- 2,7
Red ish yellow ditto,	-	9	- 2,6
Shoerl,	-	10	-
Tourmaline,	-	10	-
Quartz,	-	10	- 2,7
Opal,	-	10	- 2,6
Chrysolite,	-	10	- 3,7
Zeolyte,	-	8	- 2,1
Fluor,	-	7	-
Calcareous Spar,	-	6	-

Gypsum

Table of Hardness:

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Gypsum,	-	-	5	-
Chalk,	-	-	3	-

Remarks.

1st. Artificial gems are easily distinguished from the natural, by their softness, fusibility, solubility in acids, and in many cases by their specific gravity.

2^{dly}. Stones whose hardness does not exceed 11 may be scratched by steel.

3^{dly}. It is remarkable that opal whose hardness is equal to that of quartz, does not strike fire with steel, as Mr. *Bergman* attests, is this owing to its brittleness? but it seems that opals are of different degrees of hardness, for Mr. *Quist* in a letter to Mr. *Rinman*, mentions his having seen opals nearly as hard as diamond. *Mem. Stock.* 1766.

P A R T

P A R T II.

Saline Substances.

ALL those substances which are known *only* by this denomination, require less than two hundred times their weight of boiling water to dissolve them.

They have mostly a peculiar taste, and those of the mineral kind are uninflammable.

C H A P. I.

Of Acids.

The *Acids* to be met with in the mineral kingdom, are the *aerial*, the *vitriolic*, the *marine*, the *sparry*, the *succinous*, *phosphoric*, *molybdenous*, *arsenical*, and *tungstenic*.

The *Aerial Acid* is found either in an aerial state, as in mines, caverns, wells, or combined with water in mineral or common springs, or combined with absorbent earths, or in ores, &c. it is easily known by its property of extinguishing lights, uniting to water, and then precipitating lime water, but not a solution of nitrous selenite.

The

The *Vitriolic* when dephlogistigated, is always united to water, and as in the Earth, it must meet with bodies with which it is capable of combining, I believe it has never been found free from all combination, though it may unite to some bodies beyond the point of saturation. It is true Mr. *Baltassari* says, he found some dry concentrated acid, adhering to selenite in a grotto in *Monte Zaccolino* near *Sienna*. 7 *Roz.* but this has been fully disproved by the subsequent observations of Mr. *Murray*, in the 37th vol. of the *Memoirs of Stockholm*. In a combined state it is found in various neutral salts.

The *phlogistigated* or fulphurous vitriolic acid, frequently occurs in a free aerial state, bursting from volcanic mountains, and also in some caverns and mineral waters.

Of the other acids, none has hitherto been found in an uncombined state, except the *sedative*, which has lately been found by Mr. *Hæffer*, dissolved in the *Laguni*, or lakes of hot mineral water near *Monte Rotundo*, *Berchiaio*, and *Castelnuovo* in *Tuscany*, in the proportion of nearly 9 grains in 100 of water. Mr. *Mascagni* has likewise found it adhering to shistus on the borders of the lakes, of a dirty white, yellow or greenish colour, and crystalized in the form of needles, 16 *Roz.* 364.
This

This Salt requires at least 20 times its own weight of boiling water to dissolve it, and 50 times its weight to keep it in solution. It is also soluble in hot spirit of wine, and this solution burns with a greenish flame. Its solution in water, when heated, turns that of litmus red. It vitrifies in a moderate heat, but the glass so formed is again soluble in water. Its specific gravity is 1,479.

The *Nitrous Acid*, though generally ranked among the mineral acids, can scarce be called so, as it always requires for its formation, the putrefaction of animal or vegetable substances. It is never found disengaged from all bases (except perhaps in charnels and privys), but always united either to alkalis or Earths.

The *Marine Acid* is found only in a state of combination with alkalis, earths and some metals.

The *Sparry* is found in fluor spars, lapis lazuli, chrysoprasium, and phosphoric blende.

The *Succinous*, found only in amber.

The

The *Phosphoric* has as yet been discovered only in fossil bones, and in one species of lead ore. It probably owes its origin to the decomposition of bones.

The *Molybdenous* acid being very lately known, has been found only in molybdena.

The *Arsenical* acid has been traced in the ores of other metallic substances, particularly of cobalt.

The *Tungsten* acid has hitherto been found only in the calcareous stone, called Tungsten.

C H A P. II.

Of Alkalis.

These are of two sorts, fixed and volatile; the fixed are either of vegetable or mineral origin, which differ in a few properties, but it is to be observed, that some vegetables afford also an alkali intirely fimilar to that of mineral origin, particularly marine plants, or those that grow near the sea; neither of them is ever found in a caustic state, but all are combined at least with the aerial acid. They then effervesce with most other acids, turn infusions of blue flowers of certain vegetables
N green,

green, crystalise with the three ancient mineral acids, &c.

The *Vegetable Alkali* is seldom found in the earth, except in wells in towns, as at *Doway*, &c. 4 *Mem. Scav. Etr.* also in the argillaceous allum ore of *la Tolfa*, and united to the nitrous acid near the surface of the earth in *Spain* and the *East Indies*, probably from the putrefaction of vegetables.

The *Mineral Alkali* is not only found in a state of combination with the vitriolic and marine acids, but also very commonly with the aerial, with which it retains, not only the name, but many of the properties of a free alkali, as the aerial acid is easily expelled. In this mild state it is easily known by its crystalization, solubility in 2,5 times its weight of water, in the temperature of 60, efflorescence by exposure to the air, effervescence with acids, and the properties of the different neutral Salts, resulting from its union with the different acids, decomposing *terreno-neutral* and ammoniacal Salts, &c.

100 Parts of this alkali, when perfectly pure and recently crystalized, contain according to Mr. *Bergman*, 20 of mere alkali, 16 of aerial acid, and 64 of water ; my determination

termination was something different from this, but then the Salt had lost some of its water by exposure to the air.

This alkali is found in *Hungary* in marshy grounds of an argillaceous or marly nature, either mixed with earth, or crystalized and efflorescing. In *Egypt* it is found at the bottom of lakes, dried up by the summer's heat. Also in the province of *Suebena*, 28 days journey from *Tripoli*, where it is called *Trona*, 35 *Mem. Stock.* also in *Syria*, *Persia*, the *East Indies*, and *China*, where it is known under the name of *Kien*. It is frequently met with germinating on walls, and is by many called *Aphronitron*; also in many mineral waters. It is in its native state frequently mixed with muriatic Earth, common salt, and marine Epsom, or marine selenite.

Volatil Alkali, in a mild state, is easily known by its smell, its volatility and its action on copper, the solutions of which, in the mineral acids, are turned blue by it. It is frequently found, though in small quantity, in mould, marl, clay, shistus, and in some mineral waters according to *Malouin. Mem. Par. 1746. Phil. Transf. 1767. 2 Bergm. Erde Kugel. 304.* It probably derives its origin in the mineral kingdom from

the putrefaction or combustion of animal or vegetable substances. In a caustic state it never occurs,

C H A P. III.

Of Neutral Salts.

These consist of an acid, united either to an alkali, Earth, or metal, of each of which combinations we shall treat in their order.

SPECIES I.

Tartar Vitriolate,

This is very seldom found native; Mr. *Bowles* says it is contained in some Earths in *Spain*. *Bowles Spain*, 68.

It requires about 16 times its weight of water to dissolve it in the temperature of 60, and only 5 of boiling water, it forms non deliquescent permanent crystals, decrepitates when heated, but loses but little of its weight, is of very difficult fusion, precipitates the nitrous solutions of silver, lead, mercury, and chalk, is not rendered turbid by the addition of any alkali, but the acid of tartar dropped into its solution, forms a precipitate,

100-Parts of tartar vitriolate, contain about 31 of real acid, 63 of alkali, and 6 of water.

Glauber's

SPECIES II.

Glauber's Salts.

It is found native in some lakes in *Siberia*, in several mineral waters, and in the sea, as some say; also in several parts of *Dauphiné* and *Lorraine* in the Earth, and sometimes germinating on the surface. *Monnet Minéralogie*, 439.

Its characters are the same as those of tartar vitriolate, except that it requires but 3 times its weight of water to dissolve it in the temperature of 60; its crystals moulder by exposure to the air, and by heat lose half their weight. The acid of tartar causes no precipitation when instilled into its solution.

100 Parts of this Salt contain about 14 of real acid, 22 of alkali, and 64 of water.

SPECIES III.

Vitriolic Ammoniac.

This is said to have been found in the neighbourhood of volcanos, particularly of *Mount Vesuvius*, where, indeed, it might well have been expected; yet its existence is rendered somewhat dubious, since Mr. *Bergman* could scarce find any trace of it among the various specimens of salts from *Vesuvius*,

N 3

which

which he examined, 3 *Bergm.* 236. and the reason probably is because the vitriolic acid, disengaged by the combustion of sulphur, is in a phlogisticated state, and all its combinations in this state are easily decomposed by the marine acid which plentifully occurs in volcanos. It is also said to be found in the mineral lakes of *Tuscany*, 16 *Roz.* 363. which is much more probable, as the vitriolic acid when united to water easily parts with phlogiston, and recovers its superiority over other acids: also on the surface of the Earth in the neighbourhood of *Turin*.

Vitriolic Ammoniac is easily known: for if quick lime or fixed alkali be thrown into its solution, the smell of the volatil alkali is perceived; and if this solution be poured into that of chalk or ponderous Earth in the nitrous acid, a precipitate will appear. 100 parts of it contain about 42 of real acid, 40 of volatil alkali, and 18 of water.

SPECIES IV.

Selenite.

I have already mentioned this substance among the calcareous Earths. It is frequently found in mineral and common springs, and also in sea water. Its taste is
neither

neither bitter nor astringent, but earthy. Its solution mixes uniformly with that of nitrous or marine Selenite, but is precipitable by fixed alkalis, mild or caustic, and also by the saccharine acid, but not by volatile caustic alkali, which distinguishes it from *Epsom* and alum.

SPECIES V.

Epsom.

Many mineral waters contain this salt, particularly those of *Epsom*, *Egra*, *Sedlitz*, and *Seydchütz*: it has also been found native, mixed with common salt and coaly matter germinating on some free stones in coal mines. 8 Roz. 137.

This salt, in the temperature of 60, requires about its own weight of water to dissolve it; its taste is bitter; it effloresces by exposure to the air, when heated it loses nearly $\frac{1}{2}$ its weight by evaporation; its solution is rendered turbid by a mixture with that of nitrous or marine selenite, which distinguishes it from solutions of selenite, but preserves its limpidity when mixed with a solution of nitrous or marine *Epsom*; its earth is precipitable by all alkalis in any state, and also by lime.

100 parts of it contain about 24 of real acid, 19 of earth, and 57 of water.

SPECIES VI.

Alum.

Alum requires about 15 times its weight of water to dissolve it in the temperature of 60. Its taste is well known; it swells and blisters when heated, and loses nearly $\frac{1}{2}$ its weight. It is precipitable by all alkalis, and even by magnesia, which distinguishes its basis from that of *Epsom*: but the precipitate retains nearly $\frac{1}{2}$ the weight of the acid with which it was originally united, and is in reality *Embryon Alum*; but by digesting it in volatile alkalis (for its basis would unite to fixed alkalis) it may be perfectly purified. Its solution, like that of *Epsom*, renders nitrous solutions of silver or chalk turbid, but mixes uniformly with those of nitrous or marine alum, or of the vitriols of any metal: these properties distinguish it sufficiently.

100 parts of it contain about 24 of acid, 18 of earth, and 58 of water.

This salt is found native in a few mineral springs*, though rarely, 1 *Bergm.* 280. and

* *Margr. 2 Theile, 193.*

in the mineral lakes of *Tuscany*, 16 *Roz.* 362. also germinating on the surface of free stone or shistus in coal mines, or on lavas near volcanos, and on several rocks in the *Archipelago*, and in several parts of *Hungary*, *Bohemia*, and *Switzerland*, though seldom pure; but far the greater part of it is factitious, being extracted from various ores, the principal of which are the following:

SPECIES VII.

Aluminous Ores.

1st. *Sulphurated Clay*. This constitutes the purest of all aluminous ores, namely, that of *La Tolfa* near *Civita Vecchia*; it is white, compact, and of the hardness of indurated clay; hence called *Petra Aluminaris*, yet mealy and tasteless. Mr. *Monnet* first discovered the real nature of this ore. According to him 100 parts of it contain upwards of 40 of sulphur, and 50 of clay, besides a small quantity of fixed vegetable alkali, and a very minute portion of iron. 13 *Roz. Supplem.* p. 338. With this Mr. *Bergman's* analysis nearly agrees; 100 parts of this ore containing, according to him, 43 of sulphur, 35 of argill, and 22 of flix. 3 *Berg.* 271. He also found the vegetable alkali and iron, but probably he did not separate them, but reckoned

reckoned them among the argillaceous contents, which must also have contained a quantity of vitriolic acid: To make this ore produce alum, it is necessary that it should first be torrefied to decompose the sulphur, whose acid then re-acts on the argill, and being moistened, or exposed to the air, it soon swells, effloresces, and forms alum. This ore was probably at first a clay, mixed with sulphur, and hardened by volcanic fire, and derives its alkali from vegetables incinerated by the volcano. Mr. *Monnet* found also a little magnesia in this ore. *Mineralog.* p. 160. The red colour of the alum proceeds from iron in a particular state. 3 *Bergm.* 250.

2^d *Pyritaceous Clay.* This is found at *Schwemfal* in *Saxony* at the depth of 10 or 12 feet; it is a black, hard, yet brittle substance, consisting of clay, pyrites and bitumen; after it is dug it is left exposed to the air for two years, by which means the pyrites are decomposed, and alum formed. 3 *Jars Voy. Metallurg.* p. 293. The alum ores of *Hesse* and *Liege* are also of this species, yet they are torrefied; a practice which *Jars* condemns. According to *Monnet* this ore contains also magnesia. *Mineralog.* p. 164. 64 pounds of this ore yield from 5 to 7 of alum. An earth of this species, of a foliated

foliated texture, is also found in *Burgundy*, and is by some called *Ampelytes*. 1 *Chym de Dijon*. p. 107.

3^d *Shistus Aluminaris*. This differs from roof shistus in this, that it contains a variable proportion of pyrites intimately mixed with it, and also *Petrol. Bergm. Sciagr.* and 1 *Bergm.* 292. Its colour is blue or black, but when the proportion of petrol is very small, grey. When the proportion of pyrites is so large as to form a visible mass, the ore is commonly rejected as containing too much iron, though it might be worked to advantage, by adding a proportion of clay; a valuable improvement suggested by Mr. *Bergman*. When the proportion of petrol is considerable, it does not effloresce by exposure to the air, and therefore must be torrefied to burn off the petrol, and extricate the acid from the sulphur of the pyrites; but when the proportion of petrol is small, the pyritical part is decomposed by long exposure to the air and moisture; and thus alum is formed. In *Sweden*, if 100 pounds of the ore yield 4 of alum, it is worth working; but it generally yields more. The mine of *Becket* in *Normandy*, and those of *Whitby* in *Yorkshire*, are of this species.

4th. *Volcanic Aluminous Ore*. This is found at *Solfatara* near *Naples*, and elsewhere,

where, in the form of a white saline earth. In this ore alum is formed by the action of the phlogisticated vitriolic acid on argillaceous lavas.—100 parts of it contain, according to Mr. *Bergman's* analysis, 88 of siliceous earth, 4 of argillaceous, and 8 of alum; but this proportion is variable. Before efflorescence it is in a stony form.

5th. *Bituminous Alum Ore.* Shale. 2 *Watson*, 314. This is a shistus impregnated with so much coaly matter or bitumen as to be inflammable; it also contains sulphur. 120 parts of calcined shale afford 1 of alum; it is found in *Sweden*, and among the coal mines at *Whitehaven*, and elsewhere. 8 *Roz.* 141.

Alum might also be extracted from many species of pyrites, but so contaminated with iron as scarce to quit cost; so also from calamine and pyritaceous wood.

Native alum, mixed with vitriolic ammoniac, is found crystalized on the borders of the mineral lakes of *Tuscany*. 16 *Roz.* 363. it is also found in a capillary form near the lake of *St. Agnans*, in the grotto of *St. Germano*. 37 *Mem. Stock.*

SPECIES VIII.

Vitriol of Iron.

It is of a greenish colour when perfectly and recently crystalized, but effloresces by exposure to the air, and becomes yellowish: it requires 6 times its weight of water to dissolve it in the temperature of 60; its acid is known by this, that the solution of this salt mixes without turbidity with the solutions of other salts that contain the vitriolic acid, as Epfom, selenite, tartar vitriolate, &c. but renders the solutions of nitrous or marine selenite turbid; and its basis, by the black colour which the solution of galls or vegetable astringents immediately produce in its solution.

100 Parts of it recently crystalized contain 20 of real acid, 25 of iron and 55 of water.

It is frequently found native, either in coal mines, or in the cavities of pyritaceous mines, or adhering to the scaffolds in a stalactitical form. Also in small round stones called *Ink stones*, of a white, red, grey, yellow or black colour, which are almost intirely soluble in water, and contain a portion of copper and zinc. 2 *Schlutter*, 620. 2 *Fars*, 265. Also sometimes in shistus. But the greatest part

part of that in use is prepared from the martial pyrites or mundic.

Martial Pyrites is an iron ore containing from $\frac{1}{6}$ to $\frac{1}{3}$ of sulphur, from $\frac{1}{3}$ to $\frac{1}{2}$ of iron, the remainder argill and silex, the three first intimately combined with each other, and the iron in a semiphlogisticated state. *Monnet Eaux Miner.* 281. 2 *Gerh. Beytr.* 57. It strikes fire with steel, and thence derives its name; it is generally of a yellow or grey colour, of a globular or cubic shape, internally radiated and sometimes lamellar, commonly in part soluble in nitrous acid with effervescence, and slowly in the vitriolic, with which it forms alum; it detonates slightly with nitre and is very infusible: its specific gravity is from 3,7 to 4,912. Some pyrites instead of argillaceous contain calcareous Earth, these are common in *France*, and in them the iron is in a dephlogisticated state. *Monnet Mineral.* 339. Pyrites are frequently found in a stactical shape, and often form the matter of petri actions: they are also found mixed and interspersed through almost every other species of stone except granite. According to Mr. *Monnet*, those of a filamentous or striated texture contain least sulphur, those of a lamellar, most; the last effloresce difficultly if at all, and are said to contain from 25 to 35 per cent of sulphur.

Vitriol

Vitriol is formed in these stones by exposing them a long time to the action of the air and moisture, or by torrefaction in open air, and subsequent exposition to its action, which operation in some cases must be often repeated, according to the proportion of sulphur, and the nature of the Earth; the calcareous pyrites are those in which it is most easily formed, and they effloresce the soonest, good pyrites properly treated, yield about $\frac{2}{3}$ of their weight of vitriol.

Vitriol is also prepared from mineral waters that hold copper in solution, which is precipitated by iron; this solution of iron is afterwards crystalized and always retains some copper. In *Hungary* it is prepared from pyriticaceous shistus, and in many places from a species of calamine; the vitriol of *goslaar* commonly contains a portion of zinc, as that of *Hungary* and *Saxony* does of copper; the English and French vitriols are purer, yet sometimes contain a small proportion of alum. Turf and peat are sometimes impregnated with vitriol; other earths also often contain vitriol and alum. *Mon. Mineral.* 460. This vitriol is sometimes found of a white colour on the borders of the mineral lakes of *Tuscany*.
16 *Roz.* 363.

SPECIES IX.

Vitriol of Copper.

Its colour is blue, which degenerates into a mixture of blue and rusty yellow after it has been long exposed to the air ; it requires about four times its weight of water to dissolve it in the temperature of 60. Its specific gravity is about 2,23 ; if a piece of clean polished iron be dipped into the solution of this salt, it will almost immediately be covered with a cupreous coat, this together with the deep blue colour arising from mixing it with a volatile alkali, discovers its basis, as its uniform mixture with other vitriolic salts does its acid.

100 Parts of vitriol of copper contain 30 of real acid, 27 of copper, and 43 of water. 80 Parts of good iron precipitate 100 of copper, from a solution, that does not contain a notable excess of acid.

This salt rarely occurs crystalized, but is often found naturally dissolved in water, in *Hungary, Sweden and Ireland* ; from this water blue vitriol is generally prepared. Mr. *Cronsted* says it is seldom free from iron and zinc ; it is also occasionally extracted from sulphurated copper ores after torrefaction.

Schlutt.

Schlutt. 638. According to Mr. *Cronsted*, the blue vitriol of *Goslaar* contains a mixture of zinc.

SPECIES X.

Vitriol of Zinc.

Its colour is white, it requires little more than twice its weight of water to dissolve it in the temperature of 60; its specific gravity is about 2,000; it mixes uniformly with vitriolic neutral salts, but precipitates nitrous or marine selenites from their solutions, which ascertains its acid principle; it is itself precipitated whitish by alkalis and earths, but not by iron, copper, or zinc, which sufficiently indicates its basis; if it contains any other metallic principle, this may be precipitated by adding more zinc, except iron, which will of itself precipitate by exposure to the air, or boiling in open air.

100 parts of vitriol of zinc, contain 22 acid, 20 of zinc, and 58 of water.

This salt is sometimes found native, mixed with vitriol of iron, and in the form of white hairy crystals, 2 *Linné von Gmelin*, p. 316, or in a stalactitical form in the galleries of Mines in *Hungary*, *Goslaar*, &c. or as an efflorescence on ores of zinc; it is also found dissolved in mineral waters, and generally with some proportion of the vitriols of iron and copper, 2 *Bergm.*

318, but that in common use is mostly prepared at *Goslaar* from an ore which contains zinc, copper, and lead, mineralized by sulphur and a little iron; the copper ore is first separated as much as possible, and the residuum after torrefaction and distillation is thrown red hot into water and lixiviated. *Schlutt*, 639, 3 *Jars*, 320, it is never free from iron.

The vitriols of copper, iron, and zinc, are according to Mr. *Cronsted*, frequently found mixed in the waters pumped out of mines, sometimes all three are found crystalized in lumps of a yellow colour; the vitriol of *Fahlun* in *Sweden*, contains all three, *Bergm. Sciagr.* § 82.

SPECIES XI.

Vitriol of Cobalt.

It is difficultly soluble in water, and both it and its solution are red, which sufficiently distinguishes its basis; its acid is known by the same tests as that of the former vitriols.

It is said to be found native in small pieces, mixed with a greenish efflorescence in cobalt mines, *Born, Index, Foss.* 51.

Halotrichium

Halotrichium, *Trichites*, or native alum mixed with vitriol of cobalt, is found in a capillary form in mines of gold, silver, and mercury, in *Hungary* and *Germany*. 2 *Lin. von. Gmelin* 316. the phlogisticated alkali, precipitates the cobalt which with borax gives an azure glass. 2 *Bergm.* 455.

SPECIES XII.

Vitriol of Nickel.

This is also difficultly soluble in water; both it and its solution are of a green colour; it is found native efflorescing on *Kupfernickel* and generally mixed with vitriol of iron; 1 *Mem. Sued.* 213. *Cronst.* § 123. zinc precipitates the nickel, but not the iron.

SPECIES XIII.

Vitriol of Manganese.

I do not know that this has been as yet found; as its colour and also that of its precipitate by fixed alkalis, is white, it may be confounded with vitriol of zinc; but the precipitate of the vitriol of manganese soon grows black by exposure to the air, especially if heated, and is then insoluble in the dephlogisticated nitrous acid, unless sugar be added, properties which the precipitate of zinc does not possess.

SPECIES XIV.

Vitriols of Silver, Mercury and Lead.

These I shall treat of among the ores of those metals.

SPECIES XV.

Nitre, or Prismatic Nitre.

Nitre requires about 7 times its weight of water to dissolve it in the temperature of 60: its specific gravity is 1,92, vegetable alkalis do not render its solution turbid, but the acid of tartar does; it deflagrates with burning coals, or on a red hot iron, and mixed with marine acid it makes *aqua regia*.

100 Parts of nitre contain about 30 acid, 63 vegetable alkali, and 7 of water.

It is said to be found formed by nature in certain clays in the *East Indies*, *China*, *Spain*,* and in *Siberia*, in the cavities of rocks,† also on the surface of masses of chalk, in the neighbourhood of *Roche guyon*,‡ and in some wells in great towns, as London and Berlin; but more frequently in old mortar, § some-

* 1 Watfon, 315, Bowls, *Spain*, 70, 78, *Suenk. Handl.* 1772. 2 Quart. † *Phil. trans.* 1763, p. 209. ‡ *Macq. Dict. Nitre.* § 1 Wats. 293.

times it shoots on the surface of damp walls, and is then called *salpetere de bouffage*. *Mon. Mineral*, 446, but Mr. *Lavoisier* has shewn that old mortar often contains only nitrous selenite, which is converted into true nitre by mixture with ashes, though those ashes contain a large proportion of tartar vitriolate and glauher's salt, because these salts decompose the calcareous selenite, and form nitre by the way of double decomposition, *Mem. Par.* 1777.

SPECIES XVI.

Cubic Nitre.

This salt requires but 3 times its weight of water to dissolve it, at the temperature of 60; its specific gravity is about 1,87; vegetable fixed alkali decomposes it without forming a visible precipitate in its solution, neither does the tartarous acid precipitate any thing from it; with vitriolic acid (the nitrous being expelled) it forms glauher's salt; it deflagrates like prismatic nitre, and also forms *aqua regia*, in the same circumstances.

100 Parts of cubic nitre contain about 29 of real acid, 50 of mineral alkali, and 21 of water.

According to Mr. Bowles, it is found native in *Spain*.

SPECIES XVII.

Nitrous Ammoniac.

It generally deliquesces; when mixed with a fixed alkali, the volatile betrays itself by its smell; it deflagrates when the containing vessel is heated nearly red; with spirit of salt it makes *aqua regia*.

100 Parts of it contain 46 of nitrous acid, 40 of volatile alkali, and 14 of water, as I believe.

It is frequently found in the mother liquor of nitre, *Linné von Gmelin*, 332, *Weber Abhand, von den Salpetre*, 17.

SPECIES XVIII.

Nitrous Selenite.

This also deliquesces, its taste is bitter, fixed alkalis decompose it, and form cubic or prismatic nitre, but caustic volatile alkali cannot decompose it, it does not deflagrate, yet paper moistened with a saturate solution of it, crackles on burning, it loses its acid in a strong red heat, its solution will not trouble that of silver in the nitrous acid; vitriolic acid will precipitate its basis, as will the acid of sugar.

100 parts of it contain, when well dried, about 33 of acid, 32 of calcareous earth, and 35 of water.

It exists in old mortar, and the mother liquor of nitre; also in chalk rocks near *Rocheguyon*. *Macquer's Dict. Nitre*.

SPECIES XIX.

Nitrous Epsom

Deliquesces, does not defflagrate, does not render the nitrous solution of silver turbid, is precipitated by caustic volatil alkali, and also by the acid of sugar, but the precipitation is scarce apparent, unless spirit of wine or evaporation be applied. If nitrous selenite and nitrous *Epsom* be mixed, and both solutions be saturated, a precipitate will also appear; neither vitriolic acid nor mild magnesia occasion any turbidity in its solution.

100 parts of it contain about 36 of real acid, 27 of magnesia, and 37 of water.

It exists in old mortar, and is found in the mother liquor of nitre.

SPECIES XX.

Salt of Sylvius

Requires about 3 times its weight of water to dissolve it; its specific gravity is 1,836; dissolved in nitrous acid it makes *aqua regia*; it forms a cloud in the nitrous solution of silver; fixed alkali precipitate nothing from its solution, nor does a mixture of marine felentine, but the acid of tartar causes a precipitate.

100 parts of it contain about 30 of real acid, 63 of vegetable alkali, and 7 of water.

It is found in some boggs in *Picardy*, and some mineral waters in *Normandy*. *Monnet Hydrolog.* 263.

SPECIES XXI.

Common Salt

Requires about 2,5 its weight of water to dissolve it in the temperature of 60; its specific gravity is 2,12; the acid of tartar precipitates nothing from it; in other respects it agrees with the above.

100 parts of it contain 33 real acid, 50 of mineral alkali, and 17 of water.

It

It is not only found in the sea, salt lakes, and many salt springs in the proportion of even 36 per cent. but also in large masses under the earth in many countries, as *Poland, England, Tyrole, &c.* also in coal and beds of gypsum. *Born's Index.* Its colour is either grey, red, blue, yellow or black. *Cronstedt* §. 129. *Born.*

SECTION XXII.

Sal Ammoniac

Requires about 3,5 times its weight of water to dissolve it in the temperature of 60; its specific gravity about 1,42; it makes *aqua regia* when mixed with nitrous acid; it dissolves copper; it wholly evaporates when laid on a hot iron.

100 parts of it contain 52 of real acid, 40 of volatil alkali, and 8 of water.

It is found native and of different colours, grey, black, green, red, in the neighbourhood of volcanos, and in the mineral lakes of *Tuscany.* 16 *Roz.* 362. Also in some mountains of *Tartary* and *Thibet.* 2 *Linne von Gmelin.* 335. and in the caverns or grottos of *Pouzzoli.* *Mem. Sued.* 243. also in various clays, though in small quantity. *Ibid.*

SPECIES XXIII.

SPECIES XXIII.

Marine Baroselenite.

This consists of marine acid united to barytes; it is said to have been found in some mineral waters in *Sweden*. *Bergm. Sciagr.* §. 58. It is known by its easy precipitability by the vitriolic acid, and the great insolubility and weight of the resulting compound.

SPECIES XXIV.

Marine Selenite

Deliquesces; its basis is also precipitable by the vitriolic acid, and its solution renders that of silver in the nitrous acid turbid, at the same time that it makes no change in that of nitrous selenite; it obstinately retains its acid in a red heat.

100 parts of it contain, when well dried, about 42 of acid, 38 of earth, and 20 of water.

It is frequently found in mineral waters, *Monnet*, 457, and sometimes in sea water, *Cronst.* §. 128. *Mon. Hydrol.* p. 206, 294, but not always, 1 *Bergm.* 192, probably only where the bottom of the sea is calcareous,
also

also in the salt works at *Salzburg. Born.*
Index 52.

SPECIES XXV.

Marine Epsom

Also deliquesces; its solution does not trouble that of nitrous or marine selenite, but it causes a cloud in the nitrous solution of silver; vitriolic acid makes no visible precipitate in its solution; but all alkalis, even the caustic volatil alkali, precipitate its basis; it loses its acid in a red heat.

It is found in the sea in greater plenty than any other salt, except sea salt. 1. *Bergm.*
182.

SPECIES XXVI.

Marine Alum.

This salt has not yet been found; if it exists, it may be known by its deliquescence and precipitability by magnesia, pure or mild; the mild should preferably be used, as it is most soluble.

SPECIES XXVII.

SPECIES XXVII.

Marine Salt of Copper.

This has been found in *Saxony* in the mine of *Johnsgeorgenstadt*; it is of a greenish colour and foliated texture, moderately hard, and sometimes transparent and crystalized; it has been taken for a sort of mica, but Mr. *Bergman* found it to consist of copper and marine acid, with a little argillaceous earth. 2 *Bergm.* 431. Another specimen of a purer sort, and bluish green colour, was also deposited in the museum of *Upsal*. *Ibid.*

SPECIES XXVIII.

Marine Salt of Manganese.

Mr. *Hielm* is the only person who has as yet found this salt; he discovered it in some mineral waters in *Sweden*; it is precipitated of a whitish yellow colour by the *Prussian* alkali, and of a brownish yellow by the mineral alkali; it does not crystalize in any distinct form, but attracts the moisture of the air; to obtain it free from iron, it should be precipitated by the mineral alkali, redissolved in nitrous acid, then calcined until this acid is expelled, and the residuum treated
with

with distilled vinegar, which will then take up only the manganese.

SPECIES XXIX.

Marine Salt of Mercury.

See mercurial ores, Species III.

SPECIES XXX.

Borax.

In the state in which it is naturally found requires about 18 times its weight of water to dissolve it in the temperature of 60; its specific gravity is about 1,74; it does not effervesce with the mineral acids, except they be heated, and then but slightly; when heated, it swells and loses $\frac{4}{10}$ of its weight, and in a stronger heat runs into a glass, which is redissoluble in water.

If to a saturate solution of borax, oil of vitriol be added until it becomes sensibly acid, the sedative salt will separate from the borax, and swim on the surface in the form of white scales, the filtered liquor will on evaporation yield *Glauber's salt*.

100 parts of purified borax contain 34 of real sedative acid, 17 of mineral alkali, and 47 of

of water, but of the mineral alkali only about 5 parts are really saturated, the rest is unsaturated; and hence in many cases borax acts as an alkali.

Borax comes to Europe from the *East Indies* in a very impure state in the form of large, flat hexangular or irregular crystals, of a dull white or greenish colour, greasy to the touch, or in small crystals, as it were cemented together by a rancid, yellowish, oily substance, intermixed with marl, gravel, and other impurities. In this state it is called brute borax, *chrysocola* or *tincal*.

It is purified by solution, filtration and crystallisation; and the crystals thus obtained are calcined to free them still further from greasiness, and then dissolved, filtered, and crystallized a 2d time; sometimes more mineral alkali is added, as it is said that tincal contains an excess of sedative salt.

It has been long thought that borax was a factitious substance, but it is now beyond all doubt that it is a natural production, since Mr. *Grill Abrahamson* sent some to *Sweden* in the year 1772 in a crystalline form as dug out of the earth in the kingdom of *Thebet*, where it is called *pounxa*, *my poun* and *houi poun*; as borax is purified also in the *East Indies*, Mr.
Engestrom

Engestrom suspects that the tincal is only the residuum of the mother liquor of borax evaporated to dryness, and that the greasiness arises from its being mixed with butter milk to prevent its efflorescence. It is said to have been found in *Saxony* in some coal pits. *Gerb. Beytr.* 144.

PART

P A R T III.

Inflammables.

UNDER this head I do not comprise *all* minerals that may be inflamed if exposed to a strong heat, for otherwise several sulphureous metallic ores, pyrites, and even some metallic substances, diamonds and plumbago, should be arranged under this class, which would occasion that confusion which is meant to be avoided by systematic classification, but merely those substances, which in fact are inflammable, and do not come under the denomination of Earths, Salts, or metallic ores, and have general characters perfectly distinct from them. Of these some are fluid, some liquid, and some solid; the specific gravity of the latter never exceeds 2,5, and the former are the lightest of all bodies. The French bestow the name of *Bitumen* upon all liquid and solid mineral inflammables, except sulphur; the Germans by that name denote only the solid. These are all, except coal, electrics, *per se*, and insoluble in water and spirit of wine, but soluble in some species of oil. Mr. *Bergman* says he possesses a concrete rape-seed oil, which is hard and pellucid like copal, and insoluble in water and spirit of wine. 2 *Erde. Besch.* 267.

SPECIES I.

SPECIES I.

Inflammable Air, Fire Damp.

This is easily known by its property of inflaming, when mixed with twice or thrice its bulk of common atmospheric air. When pure, it explodes all at once, but when mixed or combined with fixed air, it burns with a blue lambent flame. It frequently occurs in coal-pits and mines, and often on the surface of springs in *Persia*, *Italy*, and *France*, and seems to be nothing more than the exhalation of petrol.

SPECIES II.

Hepatic Air.

This air seems to consist of sulphur, held in solution in vitriolic or marine air; it is inflammable when mixed with $\frac{3}{4}$ of its bulk of common air. Water will take up about $\frac{1}{2}$ its bulk of this air, and when saturated with it will turn silver black, but if strong dephlogisticated nitrous acid be dropped into this water, the sulphur will be precipitated.

100 Cubic inches of this air, when united to water, may hold 8 grains of sulphur in
P solution,

solution, in the temperature of 60, and more if hotter. Pure air also decomposes hepatic air.

It is found in many mineral waters, and particularly in the hot baths of *Aix la Chapelle*. The cause and manner of their containing sulphur, which was long a problem, has at last been happily explained by Mr. *Bergman*. It plentifully occurs in the neighbourhood of volcanos, and in several mines.

SPECIES III.

Naphtba.

A fine thin fragrant colourless oil, which issues out of white, yellow, or black clays in *Persia* and *Media*, is known by this name. It burns with a bluish yellow flame, and is as inflammable as æther, and like it, extracts gold from *Aqua Regia*. It is not decomposed by distillation, and yet if long exposed to the air, it changes colour, thickens, and degenerates into petrol. Its smell is very different from that of vegetable oils; it dissolves resins and balsams, but not gum resins, nor elastic gum. It dissolves the essential oils of thyme and lavender, but is insoluble in spirit of wine and æther. Its specific gravity is 0,708.

SPECIES

SPECIES IV.

Petrol, Bergoel, Steinoel.

Doctor *Priestley* has shewn in the 3d volume of his *Observations and Experiments on Air*, that essential oils, long exposed to the atmosphere, absorb not only the pure part, but also the phlogisticated part of it. An absorption, which must, in time, produce considerable changes in them; by a process of this sort, naphtha is converted into petrol, which is an oil of various degrees of density, according to the time during which it has been exposed to the atmosphere; its colour is reddish, or yellow, brown, greenish, or blackish, it is found trickling from rocks, or issuing from the earth in the Dutchy of *Modena*, and in various parts of *France*, *Switzerland*, *Germany*, and *Scotland*, as well as in *Asia*. Also on the surface of the water of different fountains, or mixed with earth and sand, from which it is separated by infusion in water; the thinnest sort possesses the properties of naphtha, though in a lesser degree. It is rendered finer by distillation with water, and leaves a resinous residuum, and if distilled with a volatil alkali, the alkali acquires the properties of succinated ammoniac, and hence contains the acid of amber. Some sorts of it, according to *Monet*, are nearly

of the density of nut oil. It is insoluble in spirit of wine.

SPECIES V.

Barbadoes tar, Erdepech, Bergtheer, Kedria-terreſtris, Maltba.

Petrol long expoſed to the air, forms this ſubſtance. It is of a viſcid conſiſtence, of a brown, black, or reddiſh black colour, ſometimes inodorous, but generally of a more or leſs diſagreeable ſmell, particularly when burned. It eaſily melts, and burns with much ſmoke and foot, and leaves either aſhes or a ſlag, proceeding from heterogeneities contained in it. Spirit of wine cannot diſſolve it. It contains a portion of the ſuccinous acid, for with mineral alkali it gives a bitter ſalt, more difficultly ſoluble than common ſalt, and which treated with charcoal, will not afford ſulphur. *Mem. Berlin, 1758.*

It is found in *Persia*, in the neighbourhood of *Petrol*, in ſtrata of gypſum and liſe-ſtone, or floating on water, alſo in *Siberia*, *Germany*, *Switzerland*, and in coal-pits, alſo in *America*.

SPECIES VI.

Asphaltum, Iudenpech, Bergbartz, Steinpech, Erhartete Bergtheer.

This is a smooth, hard, brittle, inodorous black or brown substance; it breaks with a smooth shining surface, melts easily when heated, and when pure, burns without leaving any ashes, but if impure, leaves ashes or a slag. According to Mr. *Monnet*, it contains sulphur, or at least the vitriolic acid, which seems confirmed by the experiments of Messrs. *Gerhard** and *Tbory*,† it is slightly and partially acted on by Alcohol and æther.

It is found on the shores of the Red Sea, also in *Sweden, Germany, and France.*

SPECIES VII.

Mineral tallow, Mumia, Belessoon.

This was found in the sea on the coasts of *Finland*, in the year 1736; it is perfectly white, and of the consistence of tallow, but more brittle, though as greasy. Its specific gravity is 0,770, whereas, that of tallow is 0,969; it burns with a blue flame, and a smell of grease, leaving a black viscid matter, which is more difficultly consumed, it is soluble in spirit of wine only when tartarised, and even

* 2 Beytrage. † 6 Crell Chemische Journal, p. 67.

then leaves an insoluble residuum, but expressed oils dissolve it when boiling. It is also found in some rocky parts of *Persia*, but seems mixed with petrol, and is there called *Schebennaad, Tshenpen, Kodreti*.* Mr. *Herman*, a physician of *Straßburg*, mentions a spring in the neighbourhood of that city, which contains a substance of this sort diffused through it, which separates on ebullition, and may then be collected. 3 *Roz.* 346.

SPECIES VIII.

Jet, Gagates, Lapis Obsidianus.

Jet is much harder than asphaltum, always black, susceptible of a good polish and glassy in its fracture, which is conchoidal; it is highly electrical; its specific gravity is 1,744; it melts in a moderately strong heat with a disagreeable smell, when burnt it leaves a grey earthy ochrous residuum; it is insoluble in spirit of wine.

It is found in *England, Scotland, France, Italy, Germany, &c.*

SPECIES IX.

Pitt or Stone Coal. Lithanthrax.

Coal is a black, solid, compact, brittle, inflammable substance, of a moderate hardness,

* *Mem. Sued.* 87. 2 *Lin. von Gmel.* 389. 2 *Gerh. Beytr.* 211.
laminated

laminated texture, more or less shining, but rarely susceptible of a good polish, does not melt when heated, and always leaves some ashes; it seems to consist of petrol or asphaltum intimately mixed with a small proportion of Earth, mostly argillaceous, seldom calcareous, and often with pyrites; according to Mr. *Gerhard*, spirit of wine extracts a red colour from it, caustic fixed alkali attacks the bituminous part, and fat oils act on and form a varnish, at least with some sorts of it: a fixed alkali has never been found in it, nor any sulphur, except it contained pyrites. Four varieties of it deserve to be distinctly considered: none of them are electrics *per se*.

I. and II. VARIETY.

Cannel Coal, and Killkenny Coal.

Cannel coal is of a dull black colour, breaks easily in any direction, and in its fracture presents a smooth conchoidal surface, if broken transversely; this sort contains most petrol and in a less dense state; hence it burns with a bright lively flame: its specific gravity is about 1,27; *Killkenny* coal contains the largest proportion of dense petrol or asphaltum: and hence burns with less flame and smoke, and more slowly though intensely, the quantity of Earth in this coal does not exceed $\frac{1}{10}$ of its weight: its specific

P 4

gravity

gravity is about 1,4, it is frequently mixed with pyrites.

III. VARIETY.

Coal containing a moderate proportion of Petrol and Bitumen.

This burns with more or less flame according to the proportion of petrol; in its fracture, it presents a rougher surface than *Cannel* coal: its specific gravity is from 1,3 to 1,37; the best coal is of this sort, by distillation it affords first fixed air, then an acid liquor, afterwards inflammable air, and a light oil of the nature of petrol, then a volatil alkali, and lastly a dense pitchy oil; the residuum is nearly $\frac{1}{4}$ of the whole, and being slowly burnt, affords 13 per cent. of ashes, which is mostly argillaceous Earth, of which $\frac{3}{100}$ or thereabouts is magnetic. *Mem. Stock.* 1781.

100 Parts of this coal contain about 17 of Earth, of which 4 are martial; hence we see that coal does not consist of a shistus penetrated with petrol, as many have thought, for then a large proportion of silex, magnesia, and calcareous earth should be found in it.

IV. VARIETY.

IV. VARIETY.

Sulphureous Coal.

This consists of the former mixed with a notable proportion of pyrites: hence it is apt to moulder and break when exposed to the air, and contains yellow spots that look like metal; it burns with a sulphureous smell, and leaves red ashes, or a slag; water acts upon it after it has mouldered: its specific gravity is 1,5, or more.

Besides these varieties, shistus, micaceous shistus, and gneiss are frequently found in the neighbourhood of coal-mines so penetrated with petrol or bitumen as to constitute an inferior species of coal, but the bitumen being burnt, they preserve their form, and in some measure their hardness; I have also seen grey flates so soft as to be scraped with the nail, and which were greasy to the touch, that burned like coal.

All the different species of coal arise from a mixture of the varieties here enumerated.

Note. That wherever coals exist, flates are found near them, and salt or mineral springs often in their neighbourhood.

SPECIES X.

SPECIES X.

Bovey Coal, Taub Kohle. Xylanthrax.

This is of a brown, or brownish black colour, and lamellar texture, the laminæ are frequently flexible when first dug, though generally they harden when exposed to the air; it consists of wood penetrated with petrol or bitumen, and frequently contains pyrites, alum, and vitriol; its ashes afford a small quantity of fixed alkali, according to the German chymists; * but according to Mr. *Mills* they contain none; † by distillation it yields an ill smelling liquor, mixed with volatil alkali and oil, part of which is soluble in spirit of wine, and part insoluble being of a mineral nature.

It is found in *England, France, Italy, Switzerland, Germany, Iceland, &c.*

SPECIES XI.

Peat Geanthrax.

There are two sorts of inflammable substances known by this name; the first and principal is of a brown, yellowish brown, or black colour, found in moory grounds,
and

* 2 *Gerb. Beytr.* 271. † *Phil. Trans.* 1760,

and when fresh of a viscid consistence, but hardens by exposure to the air ; it consists of clay, mixed with calcareous earth and pyrites, and sometimes contains common salt ; while soft it is formed into oblong pieces, and the pyritaceous and stony matters are separated ; when distilled it affords water, acid, oil and volatil alkali, and its ashes contain a small proportion of fixed alkali ; they are either white or red according as it contains more or less ochre or pyrites. 2 *Ed. Essays*, 244. 2 *Gerh. Beytr.* 265. It is found in *Scotland, Holland, and Germany*. Another sort is found near *Newbury* in *Berkshire* ; it contains but little earth, but consists chiefly of wood branches, twiggs, roots of trees, with leaves, grass, straw and weeds. *Phil. Transf.* 1757. p. 110.

SPECIES XII.

Turf.

This consists of mould interwoven with the roots of vegetables ; when these roots are of the bulbous kind, or in large proportion, they form the looser and worst kind of turf ; but when mixed with a considerable proportion of peat, they form what is called *stone turf* ; it at first hardens, but at last crumbles by long exposure to the air.

SPECIES XIII.

SPECIES XIII.

Amber, Bernstein, Agtstein, Succinum, Electrum, Carabé.

Amber is a hard, brittle, tasteless substance, sometimes perfectly transparent, but mostly semi-transparent or opaque, and of a glossy surface; it is found of all colours, but chiefly yellow or orange, and often contains leaves or insects; its specific gravity is from 1,065 to 1,100; its fracture is even, smooth and glossy; it is capable of a fine polish, and becomes electric by friction; when rubbed or heated, it gives a peculiar agreeable smell, particularly when it melts, that is, at 550 of *Fahrenheit*, but it then loses its transparency; projected on burning coals, it burns with a whitish flame, and a whitish yellow smoke, but gives very little foot, and leaves brownish ashes; it is insoluble in water and spirit of wine, though this latter when highly rectified extracts a reddish colour from it, but it is soluble in the vitriolic acid, which then acquires a reddish purple colour, and is precipitable from it by water; no other acid dissolves it; nor is it soluble in fixed alkalis, nor in essential oils, nor in expressed, without some decomposition, and long digestion; but balsams dissolve it readily; 75 gr. of it alkalise 100 of nitre,

nitre, and therefore 100 gr. of it contain nearly 90 of phlogiston ; by distillation it affords a small quantity of water, an oil of the nature of petrol, and a peculiar acid called the fuccinous acid. *Stockar*, p. 1, 11, 17, &c. According to *Baumer Reg. Men.* 22. 100 gr. of amber afford about 72 of petrol, and 4,5 of salt, that is, fuccinous acid; the remainder was fixed, or water.

It is found in masses of different sizes in several pits in *Germany*, particularly in *Prussia*, but the best sort is that which is taken out of, or cast on shore by the sea. According to *Mr. Scheele* amber yields by distillation an aqueous acid, which possesses all the properties of vinegar ; if so, it is probably of vegetable origin. *Scheff. Forles.* §. 68. *Anmerk.*

Ambergris, Ambra.

This is a grey, brown, yellowish, black or brown substance, of the consistence of wax, and an agreeable smell, lighter than water, and easily inflammable, cast up by the sea on the coasts of *Madagascar*, *Coromandel*, &c. but as *Dr. Swedjar* has lately proved it to be of animal origin, I shall take no further notice of it.

Copal.

Copal.

Mr. *Lehman* and many others rank this also among minerals; but Mr. *Blösch*, in a still later dissertation, has satisfactorily proved that it belongs to the vegetable kingdom. ² *Beschäft. Berl. Gesellsch.* p. 91.

SPECIES XIV.

Sulphur, Brimstone.

Sulphur is a tasteless, hard, brittle, idioelectric substance, of a yellow or greenish yellow colour, whose specific gravity is from 1,9 to 2,35. According to Mr. *Bergman* it gently evaporates at 170, melts at 185, and flames at 302 of *Fahrenheit*. ³ *Bergm.* 242. It burns with a blue flame, and a disagreeable suffocating smell; in close vessels it sublimes without decomposition, or only a decomposition proportionable to the quantity of air they contain; when melted it becomes red, but recovers its colour on cooling.

It is insoluble in water, though by long trituration it is said water will take up some of it, but I believe it is rather diffused thro' than dissolved in it; neither can spirit of wine unite to it, except when both are in a vaporous state, and then 72 parts of spirit of wine

wine take up 1 of sulphur; it is soluble in hot oils, and also in fixed alkalis both in the dry and liquid way; it is decomposed by boiling in concentrated nitrous acid, partly decomposed and partly dissolved by the vitriolic, and dephlogisticated marine acid; it consists of vitriolic acid and phlogiston united nearly in the proportion of 3 to 2; for 100 gr. of sulphur contain about 60 of acid, and 40 of phlogiston.

It is found native either in solid pieces of indeterminate shape, running in veins thro' rocks, or in small lumps in gypsums and lime-stones, and in considerable quantity in *solfatera* and the neighbourhood of volcanos, or crystalized in pale, transparent or semi-transparent, octagonal or rhomboidal crystals, in the cavities of quartz, and particularly in the matrixes of ores, or in the form of small needles over hot springs, or near volcanos, and sometimes in old privies.

2^{dly}. *United with clay*, as in the aluminous ore of *la Tolfa*, and also at *Tarnowitz* in *Silesia*. The former has been already described, the latter is a light grey earth, which when dry bursts in water like marl, possesses a strong peculiar smell like camphor. If it be distilled, some sulphur sublimes.

100 gr. of this earth afford 8 of sulphur, besides gypsum, and a small quantity of iron. *Mem. Berl.* 1757.

3^{dly}. *Mixed with clay, iron and selenite.* This compound is of a grey, brown or black colour, found near *Rome*, in *Anvergne*, *Spain* and *Iceland*. 2 *Lin. von. Gmelin.* 447.

4^{thly}. *United to lime-stone*, in the form of a calcareous hepar. This is found at *Tivoli* near *Rome*, and elsewhere in *Italy*. *Mem. Par.* 1770, p. 6. or dissolved in mineral waters; 3 pounds of which sometimes contain 25 gr. of sulphur. 2 *Gerb. Beytr.* 17. It often forms incrustations on the brinks of these springs.

5^{thly}. *In the form of an alkaline hepar.* This is said to be found in some waters in *Russia*. *Schab. Samm.* 4 *Theil.* p. 544. also at *Tivoli*.

6^{thly}. *United to iron and clay* in pyrites.

Lastly, United to various metallic substances, as shall be seen in the next part.

At *Ramelsberg* and the *Hartz* they extract sulphur from the sulphureous ores of silver, and lead mixed with pyrites, by sublimation during the torrefaction of those ores: this forms

forms *crude sulphur*, which is purified by a 2d sublimation; but in *Bohemia* and *Saxony* they obtain it by immediate distillation from the pyrites, and this is again purified by sublimation in close vessels. 2 *Schlut.* 222. Most of that used here comes from *Italy*.

Sulphur is discovered in earths or stones either by its inflammation, or by distillation, with or without white arsenic or mercury, or by solution of the matrix in marine, or dilute nitrous acid, or by digestion in, or fusion with fixed alkalis.

Q

P A R T

P A R T IV.

Metallic Substances.

1. **M**ETALLIC substances are opaque bodies, whose specific gravity exceeds 5,000, consisting of a heavy, dull, brittle earth combinable with phlogiston, and during that union possessing a peculiar shining appearance. They are all conductors of electricity, and more perfectly so than any other bodies during their union with phlogiston. They are all soluble either in the nitrous acid, or in aqua regia, and all precipitable in some degree by caustic alkalis, and (except platina) by the *Prussian* alkali; all when dephlogisticated communicate a tinge to borax or microcosmic salt when melted with these fluxes, or render them opaque; all melt in some degree of heat, and most commonly assume a convex surface, or if in small quantity a globular form when in fusion, and in that state are miscible with each other for the most part, but refuse to unite with any other unmetallic substance, even their own calces*; but when calcined they are

* Iron is an exception to this rule, for even in its reguline state it is capable of uniting to its own calces slightly dephlogisticated, and to plumbag: some of them also may contain sulphur even in their reguline state as nickel, &c.

capable

capable of union with other earths and salts. The phlogiston in all of them is in a pure state, that is, free from water and aerial acid, substances that invariably accompany it in all other compounds, except acid airs and sulphur. The more earthy part or calx of some metallic substances has been found to be of an acid nature.

2. There are 17 metallic substances now known; namely, gold, platina, silver, copper, iron, lead, tin, mercury, zinc, regulus of antimony, regulus of arsenic, bismuth, cobalt, nickel, regulus of manganese, pyrites, and regulus of molybdena.

Of these gold, silver, platina and mercury are reckoned perfect or noble metals, because when calcined they recover their phlogiston without the addition of any phlogistic substance: whereas copper, iron, lead and tin cannot be entirely reduced without such addition, and hence are called ignoble or imperfect: however, all these (even mercury when solid) are malleable to a great degree, and hence called *intire* metals; whereas zinc, regulus of antimony, regulus of arsenic, &c. are scarce at all malleable, and hence are called *semi-metals*: however zinc and purified nickel are more malleable than any of the

rest. Hence there are 4 perfect metals, 4 imperfect, 8 intire, and 9 semi-metals.

3. Metallic substances in their natural state are found either united to their full complement of phlogiston, and consequently possessing their respective and peculiar properties, and thence called *native*, or more or less deprived of their phlogiston, and the properties resulting from their union with it, most commonly, if not always, by combination with some other substance, and then they are said to be *mineralized*, because this is their most usual state in the mineral kingdom, and the substance so combined with them is called a *mineralizer*; the whole is called an *ore*; so also are earths and stones, in which metallic substances are contained in a notable proportion.

4. When the mineralizer is of a *saline* nature, and renders the metallic substance with which it is combined soluble in less than 20 times its weight of water, the compound is generally ranged among *salts*: thus the vitriols of iron, copper and zinc are rather classed with salts than with ores.

5. The commonest mineralizers are sulphur, arsenic, and fixed air: the least common are the vitriolic and marine acids; the phosphoric

phosphoric has been found only in one instance; metallic substances mineralized by fixed air are called *calciform* orès, from their resemblance to the calces formed by art.

6. It is true that some mineralogists of the first rank exclude arsenic from the number of mineralizers, as it is itself a metallic substance, saying, that with equal propriety other metallic substances that render metals brittle might be called mineralizers; they also add, that arsenic is never united to metals but in its reguline state, and therefore that the compound it forms should rather be called an *alloy* than an *ore*; and, indeed, if this last circumstance always took place, I should not hesitate to agree with them; but it seems clear to me that the calx of arsenic, and even its acid being capable of uniting with metals, (an union which the calx of no other metallic substance is capable of contracting) these metals cannot unite to that calx or acid without losing some part of their phlogiston, and consequently without being mineralized in the usual sense of that word; yet if regulus of arsenic be combined with metals without any loss of phlogiston (an union which art may produce by means of the black flux) I will allow the compound should rather be called an alloy; but such an union I believe seldom or ever takes place in the mineral kingdom.

Hence I chuse to follow the common language, which, without very cogent reasons, should never be departed from.

7. All metallic substances are therefore of necessity slightly dephlogisticated when united to sulphur; but as metallic calces, in their most dephlogisticated state, are also capable of uniting with sulphur, hence it happens that they are sometimes more and sometimes less dephlogisticated in various sulphurated ores, particularly the pyritous.

8. Metallic substances mineralized by fixed air are also sometimes more and sometimes less dephlogisticated.

9. Metallic calces always containing some foreign ingredient afford a smaller weight when reduced; and it is this last that is mostly denoted, and when the proportion of metal in any ore is assigned.

C H A P. I.

Gold.

1. The distinctive characters of gold are the following: 1^o. A specific gravity reaching to 19,64. 2^{dly}. Insolubility in all acids, except aqua regia, and the dephlogisticated
marine

marine acid, and precipitability from these acids in the form of a purple powder by solution of tin, or in a metallic form by the solution of vitriol of iron. 3^{dly}. A yellow, or reddish yellow colour when in its metallic state.

Gold exposed to the utmost heat of Mr. *Parker's* lens for some hours lost no sensible part of its weight, yet when in contact with earthy matters, it communicated a blue or purplish tinge to them, so that I believe an exceeding minute portion of it was dephlogisticated.

Gold Ores.

2. Gold being incapable of uniting with sulphur, or even with arsenic, but very difficultly and while in fusion, or with fixed air, is for that reason never found mineralized, but either native or invisibly mixed with other substances.

SPECIES I.

Native.

3. Native gold is found either *separate* from any matrix in lumps, or visible grains mixed with sand, and in this state it is found in many rivers in *France, Africa*, and elsewhere, or invisibly dispersed through large masses

masses of sand, particularly the yellowish red, or violet, and in this state it is so generally diffused through all species of Earths, though in exceeding small quantity, that Mr. *Bergman* thinks it is more universally found than any other metal, except iron. 2 *Erde. Besch.* 313. If 100 pounds of sand contain 24 grains of gold, it is said the separation is worth attending to, but in *Africa*, 5 pounds of sand often contain 63 grains of gold, or even more; the heaviest sand, which is often black or red, yields most. In *Hungary*, 10,000 pounds of sand yield but 10 or 12 grains of gold; it was extracted, but with loss. *Born, letters from Hungary.* Or visibly imbodyed in some matrix, and in this state it is found, either in a granular, foliated, or ramified form, in stones of the calcareous, but chiefly of the siliceous genus, as spar, gypsum, felspar, hornblend, jaspar, and most frequently quartz, in *Hungary, Tyrole, Siberia, &c.*

4. Gold interspersed through sand, is separated by mere mechanical means, as is amply described in the *Paris Memoirs* 1718, and 1736, and *Born's Letters from Hungary.*

5. But when it is imbodyed in Earths and stones, these may be essayed in the moist way by pounding them very fine, weighing a determinate portion, and attempting their solution,

lution, if calcareous, in nitrous acid, which will dissolve the matrix, and leave the gold at bottom untouched, or if gypseous or siliceous by digesting them in aqua regia, as long as any metallic substance is taken up, which the solution of tin, or phlogisticated alkali will indicate, and then precipitating the gold by a solution of vitriol of iron.

6. Or by Amalgamation, with $\frac{1}{10}$ of their weight of mercury, in a copper or iron vessel, in which the mercury and pulverised sand are put together with water, which is kept constantly boiling, and the mercury after some time, absorbs the gold, from which it is separated by distillation, *Lew. Com.* 194.— or by heating the sand red hot, and quenching it in water 3 or 4 times, then melting it with twice its weight of litharge, then reviving the litharge by charcoal, into lead, which then separates from the sand, and lastly, freeing the gold from the lead by cupellation. *Lewis, Ibid.*

7. Native gold is seldom found perfectly pure, being generally alloyed with silver, or copper, or iron, or all three. If such alloy be dissolved in aqua regia, the silver will remain at the bottom in the form of horn silver. If then a solution of vitriol of iron be dropped into the solution of gold, this latter will
be

be precipitated, and the copper and iron may be precipitated by the phlogisticated alkali, and separated as hereafter will be seen.

SPECIES II.

Mixed with yellow or Martial Pyrites.

8. It is found thus mixed in the mine of *Adelfors* in *Sweden*. According to *Cronsted*, § 166, 100 pounds of this ore contains but one ounce of Gold, and it is said to be hardly worth extracting. The pyrites is of a bright yellow colour, close and compact. The gold in this ore is said to be mineralized by sulphur, by the medium of iron, because it cannot immediately be extracted by aqua regia or amalgamation, but Mr. *Bergman*, though he inclines to the opinion of the mineralization of gold, yet is candid enough to own, that the gold, when extracted from this ore, being of a granular or angular form, it is very doubtful whether it was not rather mixed than truly combined with the sulphur and iron, and its proportion being exceeding small, it is not wonderful that it should escape aqua regia, more especially as the nitrous acid becomes so phlogisticated by acting on the pyrites, as not to be able to dephlogisticate the marine, and mercury, from the nature of things, can have no access to it.

9. This

9. This and such like ores, may be essayed by dissolving them in about 12 times their weight of dilute nitrous acid, gradually added, and a heat of about 120 degrees; this takes up the soluble part, and leaves the gold untouched with the insoluble matrix, from which it may be separated either by lotion, or by aqua regia, from which it is precipitable as above. The sulphur floats for the most part on the solution from which it should be separated by filtration. The solution may contain iron, copper, manganese, calcareous Earth, or argill; if it be evaporated to dryness, and the residuum heated to redness for half an hour, volatil alkali will extract the copper; the dephlogisticated nitrous acid, the Earths; the acetous, the manganese; and the marine, the calx of iron.

10 Gold may also be separated from pyrites after torrefaction, by aqua regia, *Mon. Mineral.* 277.

11. Pyrites containing gold, is also found in *Switzerland* and *Hungary*, that found in *Hungary*, contains 5 ounces of gold per quintal, *Mon. Expositions des Mines*, p. 47. the gold mines of *Norway*, are of the same nature as those of *Adelfors*, 2 *Jars*.

12. In

236 *Elements of Mineralogy.*

12. In the *dry way*, Mr. *Bergman* essays these ores, by mixing 2 parts of the ore, well pounded and washed, with one and a half of litharge, and 3 of glass, covering the whole with common salt, and melting it in a smith's forge, in a covered crucible; he then opens the crucible, puts a nail into it, covers it, and heats it again, and continues to do so until the iron is no longer attacked. The lead is thus precipitated, and contains the gold which is separated by cuppellation, *Scheff.* 239. 1 *Anmerk.*

SPECIES III.

Mixed with Arsenical Pyrites.

13. Found at *Salzbergh* in *Tyrole*, in mountains of quartz and shistus; the quintal affords only about 25 grains. It is separated by lotion, and affords a profit of between 4 and 500*l.* per an. 2 *fars.* 78.

SPECIES IV.

Mixed with a white, red, or Vitreous Silver Ore.

14. Near *Cremnitz* and *Schemnitz* in *Hungary*, 2 *fars.* 165, 195.

SPECIES

SPECIES V.

Mixed with a sulphurated Ore of Silver, Iron, Lead, and Manganese.

15. Lately found at *Nagaya* in *Transylvania*. This ore consists of small dark coloured plates of more or less brightness, inhering in quartz, and a soft whitish substance, which Mr. *Bergman* found to be manganese. Part of the gold may be extracted from it by eliquation in a cuppelling heat, its fusibility being promoted by the lead.

16. If the dark coloured plates be separated from the remaining mass, and treated with aqua regia, the gold and iron will be extracted, and may be separated as above mentioned, N^o 7. but none can be extracted by amalgamation, *Scopol. An.* 3. p. 90.

17. This ore is said to afford 10 ounces of gold per quintal, besides silver, its specific gravity according to *Gellert*, is 4,043.

SPECIES VI.

Mixed with sulphurated Iron and Copper, with Manganese.

18. This is a yellow pyrites, found also at *Nagaya*, in which gold is contained; Mr. *Bindheim*

Bindheim lately essayed this ore in a particular manner. The pyrites being well pulverised, were heated in an open crucible, until the sulphur was burnt off. The residuum while hot, was thrown into water, a reddish brown matter remained undissolved. This, when dried, was digested in 3 times its weight of aqua regia, then diluted and filtered, and æther poured on it and shaken. The æther took up the gold, and being burnt off, left it in its metallic form, 4 *Berl. Schrift.* 393.

19. In *Peru* gold is found mixed with a stony matter, not well known, and also with a red Earth, from both which it is there extracted by amalgamation, 2 *Jars.*

C H A P. II.

Platina.

1. *Platina* has as yet been found only among the gold mines of *Peru*. It comes to us in the form of large smooth grains, of an irregular figure, some of them hollow, whiter than iron, intermixed with quartz, and a ferruginous sand, and in the cavities, sometimes particles of gold, but more frequently quicksilver is found, which may be separated by distillation; whence it is conjectured, that it is not brought to us in its natural state, but that it has been separated from gold with other matters,

matters, by amalgamation. Most of its particles are friable and magnetic, but some few are malleable to a considerable degree, and may be separated by a magnet, but according to the accurate experiments of Count *Sickingen*, even these contain about $\frac{1}{3}$ of their weight of iron. Before it is separated from quartz, its specific gravity is from 6,000 to 11,000, and after that separation from 16 to 18. It is soluble only in aqua regia, or dephlogisticated marine acid, and is nearly infusible in terrestrial fires, the great burning lens of *Paris* only agglutinated its particles in 20 minutes, Mr. *Parker's* perfectly melted them in less than two. It is precipitable from its solution by salammoniac, as our late excellent chymist Dr. *Lewis* has discovered, a property by which it is easily distinguished, and separated from all other metals. It is not precipitable by the Prussian alkali, as all other metals are.

2. Its ores, if it has any, are not yet known.

3. Platina is purified from iron by reiterated coction in spirit of salt, solution in aqua regia, and precipitation of the iron, by the Prussian alkali. When pure, its colour approaches to that of silver, its specific gravity is nearly 23,000, it is not in the least magnetic.

C H A P. III.

Silver.

1. Silver is the whitest of all metals ; its specific gravity when pure is 11,695 ; it is soluble in the concentrated vitriolic acid with the assistance of heat, and in the moderately dilute nitrous acid without that assistance ; it is precipitable from both by the marine, and from the nitrous in great measure by the vitriolic ; its calces are reducible without the addition of any phlogistic matter, and it is incapable of calcination by mere heat.

SPECIES I.

Native.

2. Native silver is found in a granular, lamellar, filamentous, capillary, arborescent, or crystalized form, inhering either in baroselenite, lime-stone, selenite, quartz, chert, flint, serpentine, gneiss, agate, mica, calcareous spar, pyrites, shistus, clay, &c. also in separate masses of various sizes, some of the weight of 60 pounds, in or near the veins of most metallic substances, particularly in *Peru*, and frequently in various parts of Europe, either of a white, brown, or yellowish colour.

3. It

3. It is often diffused through sand and ochre, also in grey lime-stone in *Lower Austria*, and in a greenish clay near *Schemnitz*, or mixed with ochre, clay and calciform nickel.

4. It is seldom found pure, being generally alloyed with copper, and sometimes with a small proportion of gold, iron, or regulus of antimony*, and sometimes about 5 per cent. of arsenic†; it is separable from gold and regulus of antimony by solution in nitrous acid, and from copper and iron by precipitating it by the marine acid‡, and from arsenic by torrefaction.

100 gr. of the horn silver contain 75 of real silver; it is reducible by triturating it with about its own weight of fixed alkali with a little water, then melting the whole in a crucible, whose bottom is covered with mineral alkali well pressed, and covering the mass of horn silver also with the mineral alkali.

5. The native silver found near *Königsberg* contains so much gold as to acquire a yellow colour from it.

* *Bergm. Sciag.* §, 154. † 13 *Roz. Supplem.* p. 50.

‡ A more perfect manner of separating it from copper will be seen No. 21.

SPECIES II.

*Mineralized by Sulphur.**Vitreous Silver Ore, Glaszertz.*

6. It is found either in solid large lumps, or inhering in quartz, spar, gypsum, gneiss, pyrites, &c. of a lamellar, granular or capillary form, or crystalized; it is generally of a lead colour first, but grows black by exposure to the air, but sometimes grey or black, even when first broken; its laminæ are flexible and ductil, and even malleable in some degree, and so soft, that they may be cut with a knife; its specific gravity is 7,200 *; it is one of the richest of the silver ores.

100 parts of it contain from 72 to 77 of silver; it is rarely contaminated with any other metal besides a small proportion of iron.

7. It is found in *Hungary* near *Schemnitz*, and in *Saxony* near *Freyburgh*, particularly in the famous mine of *Himmelsfurst*.

8. It is analysed by boiling it in moderately dilute nitrous acid, using about 25 times its weight, until the sulphur is quite exhausted.

* *Gellert Anfangs*. 234.

The silver is precipitated by marine acid, or common salt, and estimated as in N^o 4. The *Prussian* alkali will shew if any other metal is contained in the solution; the gold, if any, will remain undissolved; fixed alkalis will precipitate any other earthy matters contained in the solution.

9. In the dry way, it may be reduced by melting it with the blow-pipe on charcoal; for the sulphur is dissipated, and the silver remains; or by melting it with $\frac{1}{8}$ of its weight of filings of iron, as the iron will take up the sulphur and be scorified.

SPECIES III.

Mineralized by a small proportion of Arsenic.

10. This ore is of a yellowish white colour, and of a striated texture, resembling bismuth, but much harder; it melts very easily, and if kept in fusion, it loses its arsenic, and the silver remains almost intirely pure, as it contains but very little iron; it contains about 90 per cent. of silver, and is found near *Quadanal-Canal* in *Spain*. *Mon. Mineral.* 281.

SPECIES IV.

Mineralized by a large proportion of Arsenic.

11. The proportion of arsenic in this ore is so great, that it would scarce deserve to be called

called a silver ore, if the arsenic were not easily dissipated: the quintal contains but from 4 to 6 ounces of silver; it is very soft, and easily cut, and when cut has a brilliant metallic appearance; it consists of conchoidal laminæ; it is found also at *Quadanal-Canal*.
Mon. Ibid.

12. It is reduced by evaporating the arsenic, which then leaves the silver slightly contaminated with iron.

SPECIES V.

Mineralized by Sulphur and Arsenic.

Red Silver Ore, Rothgulden ertz.

13. This is a heavy, shining substance, either transparent or opaque, mostly of a crimson or reddish colour, though sometimes grey or blackish, but when scraped or powdered always reddish; found either in shapeless masses, or crystalized in pyramids or polygons, or dendritritical, or plated or radiated incrustations, on or in matrixes of quartz, flint, spar, pyrites, sparry iron ore, lead ore, pyrites, cobalt ore, jasper, baroselenite, gneiss, &c. when radiated or striated, it is called *rothgulden bluth*. In fire it crackles and melts after it has acquired a red heat, with an arsenical smell; it detonnates with nitre, its specific

cific gravity is from 5,4 to 5,684. Mr. *Bergman* found 100 gr. of it to contain 60 of silver, 27 of arsenic, and 13 of sulphur. 2 *Bergm.* 303. but sometimes it contains even 70 per cent. of silver. The darkest ores are the richest, and these often contain a little iron; the yellowest are the poorest; the most yellow does not belong to this species, being in fact orpiment, containing 6 or 7 per cent. of silver.

14. To analyse this ore in the moist way, Mr. *Bergman* advises to boil it after it is reduced to a very fine powder in dilute nitrous acids, as in N^o 8, and to edulcorate the residuum very carefully which contains the sulphur and arsenic, which may be separated by boiling in a sufficient quantity of aqua regia: if the sulphur still retains any luna cornua, it may be separated by caustic volatil alkali.

15. In the dry way it is reduced after torrefaction by a mixture of iron and lead; the iron takes up the sulphur, and the lead the silver, which is afterwards separated by cupellation.

SPECIES VI.

Mineralized by Sulphur, and a very small Portion of Arsenic and Iron.

Black Silver Ore. Schwartz ertz, Schwartz gulden. Silber mulm.

16. This is either of a *solid and brittle* consistence, which distinguishes it from the vitreous ore, and of a glassy appearance in its fracture when recent, or of a *looser texture*, and sooty or deep black colour, like moss or thin leaves lying on the surface of other silver ores, or of those of lead or cobalt, or in clays, ponderous spar, gneiss, &c. it may contain about 25 per cent. of silver: the former is found in *Dauphiné, Hungary, and Saxony*, and contains at most 60 per cent. of silver. *Mon. Mineral.* 302. 3 *Lin. von. Gmel.* 406.

SPECIES VII.

Mineralized by Arsenic, and containing a large Proportion of Iron.

Arsenicomartial Silver Ore, Weiss ertz, Pyrites Argenteus of Henckel.

17. Mineralogists do not well agree about the ore to which this denomination belongs. I follow Mr. *Monnet*, who seems to have attended

tended to the division of ores most exactly. According to him this ore is a hard substance, of a white, shining appearance, and of a compact, lamellar or fibrous texture; the brightest is the poorest in silver; the richest gives only 10 per cent. the poorest 6 or 8 ounces: it contains no sulphur; and hence Mr. *Monnet* calls it a metallic regulus, not considering that the iron is in a calcined state, which fully proves that arsenic is a true mineralizer: the iron and arsenic are in various proportions, but the arsenic always exceeds.

It is found in *Saxony*, the *Hartz*, at *Quadanal-Canal*, &c.

18. It is essayed in the moist way, as in N^o 4.

SPECIES VIII.

Mineralized by Arsenic and Sulphur, with a small Proportion of Copper, and a still smaller of Iron.

White Silver Ore, Weissgulden.

19. It is a heavy, soft, opaque substance, fine grained or scaly, bright and shining in its fractures, of a whitish, steely or lead colour, sometimes crystalized in pyramidical or cylindrical forms, but often in amorphous grains, or resembling moss, or in the form of

R 4

thin

thin laminæ incrustating other bodies, found in quartz, spar, steellstein, pyrites, blend, lead ore, cobalt ore, sparry iron ore, fluors, &c. It is very fusible; its specific gravity 5,000 or 5,300; its proportion of silver from 10 to 30 per cent.

20. It is found, though not commonly, in *Saxony*, *Hungary*, the *Hartz*, and *St. Marie aux Mines*.

21. Mr. *Bergman* analyses this ore in the following manner. Having pulverized and weighed a certain portion of it, he attempts its solution in about 12 times its weight of dilute nitrous acid: the copper and silver are dissolved, and a white residuum remains. The silver he precipitates, not with marine acid, for this would unite also to the copper, and with the silver form a triple salt, which would also fall, but with a clean plate of copper previously weighed; the silver being in its metallic form, may immediately be weighed, and its contents known: the copper should then be precipitated by aerated mineral alkali; 194 gr. of this precipitate well dried are equivalent to 100 of copper in its metallic form; but from this last, the weight, which the plate of copper lost, must be subtracted.

22. The

22. The white residuum, containing the sulphur, arsenic and iron, is next to be examined : by boiling it in spirit of salt, the arsenic and iron are taken up; the arsenic is to be precipitated by the addition of water, and then the iron by the *Prussian* alkali; the sulphur remains undissolved, and may be treated with volatil alkali to try whether it retains any copper or horn silver. 2 *Bergm.* 418.

SPECIES IX.

Mineralized by Arsenic and Sulphur, with a large Proportion of Copper and some Iron.

Grey Silver Ore, Fahl erz.

23. This is a hard, grey, or dark grey substance, more or less brilliant, sometimes crystallized, but mostly amorphous, and is, in fact, the grey copper ore hereafter to be mentioned, Chap. 4. N^o 26, impregnated with silver, and varies much in its contents from about 1 to 12 per cent. of silver, and from 12 to 24 of copper, the remainder being sulphur and arsenic, with a little iron: the richer it is in copper, the poorer in silver, and reciprocally. Mr. *Monnet* remarks, that wherever copper is united to arsenic, silver is also found; it is the commonest of all the silver ores: the grey silver ore of *Dal* in *Sweden*

Sweden contains also regulus of antimony, and, according to Mr. *Bergman*, it contains 24 per cent. of copper, and 5 of silver; but this belongs to the next Species.

SPECIES X.

Mineralized by Arsenic and Sulphur, with Copper, Iron, and Regulus of Antimony.

Brown Silver Ore, Leber erz.

24. Its colour is mostly of a reddish brown, sometimes dark grey, sometimes it is found crystalized in pyramids, but mostly amorphous; when scraped it appears red; it contains from 1 to 5 per cent. of silver; the greatest part is copper, and the next in proportion is arsenic.

It is found in *Sweden, Germany* and *Spain*.

25. It is analysed by boiling it in about 6 times its weight of dilute nitrous acid, which will take up the silver and copper, and leave the regulus of antimony and arsenic: these being boiled in strong nitrous acid are dephlogisticated, and the arsenic becomes soluble in water; the calx of antimony remains undissolved; the sulphur may be found in a second experiment, using aqua regia instead of

Silver.

254

of the concentrated nitrous acid ; the silver and copper are separated as in N^o 21.

SPECIES XI.

Mineralized by Sulphur and Arsenic, with Iron and Regulus of Antimony.

Plumose Silver Ore, Feder ertz.

26. In point of colour this ore varies from a dull white to grey, dark blue, brown or black ; it is found in a capillary form, or, like wool, sometimes loose, at other times attached, its filaments are rigid and inflexible ; the whiter it is, the richer ; but it seldom contains even 1 per cent. of silver. It is found in *Saxony* and elsewhere. Some confound it with the foregoing.

Its analysis may be understood from N^o 21 and 25.

SPECIES XII.

Mineralized by Sulphur and Arsenic, with Cobalt and Iron.

Cobaltic Silver Ore,

27. This ore is distinguished by rose-coloured particles, of cobalt dispersed through a dark brown, blackish, or grey, and somewhat shining solid mass. It is found in
Saxony,

Saxony, and at *Allemont* in *Dauphiné*, and contains about 40 or 50 per cent. of silver, and very little cobalt; the arsenic is in an acid state, and united to the cobalt.

28. To analyse it, let it be dissolved in nitrous acid; the silver and cobalt will be taken up, and most of the iron will remain calcined, together with the arsenic; the silver may be precipitated by the marine acid, and the cobalt by an aerated fixed alkali, and its weight determined, as will be shewn in Chap. 13.

SPECIES XIII.

Mineralized by Sulphur, with Regulus of Antimony and Barytes.

Butter-milk Ore.

29. It appears in the form of thin pellicles, on granular spar.

SPECIES XIV.

Combustible Silver Ore.

30. This is black and brittle, and leaves about 6 per cent of silver in its ashes, it is a coal in which silver is found. The silver is extracted as usual by nitrous acid.

SPECIES XV.

SPECIES XV.

Mineralized by the Vitriolic and Marine Acids, with a little Iron, and sometimes with a mixture of the Vitreous Ore.

Corneous Silver Ore, Horn ertz.

31. This scarce and valuable ore is of a white, grey, pearly, or yellow, green, brown, purple, or black colour, frequently crystalized in a cubic form, sometimes resembling an Earth, easily fusible without any smoke. The black sort is friable, and easily pulverised, but the other sort is in some degree malleable, may be cut with a knife, and takes a sort of polish when rubbed. The vitreous ore mixed with the black, is soluble in nitrous acid, and may by that means be separated, the saline ores being insoluble in that acid; if pure from iron, these ores should contain 70 per cent of silver at least, but they mostly contain some portion of iron, of which some is even united to the marine acid according to *Monnet*. It is found in *Saxony, Bohemia, St. Marie aux Mines, Siberia, and Peru*. It was first essayed by *Mr. Wolfe, Phil. Trans. 1776*, and afterwards, though less exactly, by *Mr. Monnet, in 1777, see 9 Mem. Etr. p. 717*.

32. Mr.

32. Mr. *Bergman* gives the following most ingenious method of analysing these ores in the moist way.

1°. He digests this compound ore in the marine acid for 24 hours, by which means the vitriol of silver is decomposed, and the whole is converted into horn silver. He then judges of the quantity of the vitriol of silver, by the quantity of vitriolic acid let loose in the liquor, and to find how much this is, he decants the clear liquor, and drops into it a solution of nitrous baroselenite, which is immediately decomposed by the vitriolic acid, and forms true vitriolic baroselenite, of which 100 grains contain 15 of dephlegmated vitriolic acid, and so in proportion. Now 100 grains of vitriol of silver, contain 25,37 of the same dephlegmated acid, so that 25,37 grains of this acid, indicate 100 of vitriol of silver, and so in proportion, and thus the quantity of silver in the vitriol of silver is also found, as 100 grains of it contain 74,62 of silver,* and the proportion of vitriol of silver being known, that of horn silver of course, is known; but if the ore be of the black kind, after the whole is turned into horn silver, it should be digested in caustic volatil

* According to Mr. *Bergman*, 100 parts of vitriol of silver, contain but 68,75 of silver.

alkali,

alkali, which will take up the horn silver, and leave the vitreous ore. The iron, if any, should be precipitated from the first solution, by the *Prussian* alkali, after the precipitation of the baroselenite.

Uncertain Mineralizations.

SPECIES XVI.

Goose-dung Ore.

33. This is of a greenish colour, mixed with yellow and red; it is said to contain about 6 per cent of silver. Some think it a mixture of red silver ore, and calx of nickel.

SPECIES XVII.

Foliaceous Silver Ore. Silberartiges, Bergzunder, Blatter erz.

34. Its colour is *mort doré*. It is thought by some to be native silver, by others a mixture of galena, ochre, and silver, it is found in mountain cork, it is so light, that it swims on water. It contains but one ounce of silver per quintal. See *Lehman's Experiments, Mem. Berl. 1758.*

SPECIES XVIII.

SPECIES XVIII.

Mineralized by Sulphur, Arsenic and Bismuth.

35. Such ores have been talked of, but their existence has not as yet been proved.

36. Silver has also been found in the sulphurated ore of zinc called pech blend, and in that of lead called galena, particularly the latter, also in the copper pyrites, but in small quantity, as shall be mentioned in their proper places.

37. If an ore yields $\frac{1}{2}$ per cent of silver, it is generally worth extracting.

C H A P. IV.

Copper.

1. Its colour is pale red as is well known. Its specific gravity from 8,7 to 9,300, depending not only on its purity, but also on its condensation, by hammering. It is soluble not only in acids, but also in alkalis and neutral salts. It is precipitable from most acids, in its metallic form, by a clean plate of iron, and most of its acid solutions are convertible into a deep blue, by volatil alkalis. These characters are sufficient to distinguish it.

SPECIES. I.

SPECIES I.

Native.

2. Native copper, that is copper in a more or less malleable state, and either of its own peculiar, or of a grey or blackish colour, has been found either in grains, or in large shapeless solid lumps, or in a foliated, capillary, arborescent form, or crystalized in quadrangular pyramids, in or on clay, shistus, quartz, fluors, zeolytes, &c. in *Siberia, Sweden, Germany, Hungary, Transylvania, &c.*

3. It undoubtedly has sometimes been produced from precipitation by iron from waters in which it was held in solution, and this is the purest sort, but in many cases it could not have been produced in that manner, and then this sort is never very pure, but mixed either with gold, silver, or iron, or with sulphur; this last combination forms what is called *black copper*.

4. All these impurities are discoverable by solution, in nitrous acid; the gold remains undissolved in the form of a black powder, soluble in aqua regia; the silver may be precipitated by the marine acid, or still better by a clean polished plate of copper, the iron is
S separated

separated by boiling the whole as it is dephlogisticated, and rendered thereby insoluble.

Mineralized.

5. We may observe in general, that all copper ores after roasting, communicate a blue colour to volatil alkali, on digesting them in it. Before roasting, it is possible that arsenic may prevent that effect, or even sulphur, if in sufficient quantity.

SPECIES II.

Mineralized by the Aerial Acid.

Calciiform Ores.

6. Of these there are three varieties, the red, the green, and the blue, all are soluble in acids, and blacken in a moderate heat.

I. VARIETY.

Red, Minera cupri calciiformis Rubra, Minera hepatica, Leberertz.

7. We sometimes meet with this ore in a loose form, then called copper ochre, but generally it is moderately hard, yet brittle, sometimes crystalized and transparent, either in a capillary form, or in cubes, prisms, or pyramids,

pyramids : it is found in *England, Scotland, Germany, &c.* it effervesces with acids.

8. According to Mr. *Fontana*, 11 *Roz.* 511. 100 parts of it contain 73 of copper, 26 of fixed air, and 1 of water. Mr. *Bergman* also found it to contain fixed air, 2 *Bergm.* 430. The brown, or hepatic ore, contains a variable proportion of iron or pyrites, and sometimes sulphurated copper, and hence affords from 20 to 50 per cent. of copper. It is often iridescent.

II. VARIETY.

Green, Malachite, Mountain Green.

9. *Malachite* has the appearance of green jasper, but is not quite so hard, for it does not strike fire with steel ; it is either of a radiated or equable texture, generally of an oval form, and the size of an egg, but sometimes it forms capillary filaments. Its specific gravity, according to *Muschenbroeck*, is from 3,5 to 3,994 ; it is sometimes mixed with calcareous Earth and gypsum. It is found in *Norway, Siberia, &c.*

10. According to Mr. *Fontana*, 100 Parts of the purest sort, contain 75 of copper, and 25 of aerial acid and water.

11. *Mountain Green*, is generally found in a loose and friable state, rarely crystalized and indurated, often mixed with calcareous Earth and iron, and some arsenic. 100 Parts of the purest contain 72 of copper, 22 of aerial acid, and 6 of water.

III. VARIETY.

Mountain Blue, Chrysocola of some.

12. This also most frequently appears in a loose form, but sometimes indurated and even crystalized, but it is then mixed with quartz. 100 parts of it contain about 69 of copper, 29 of aerial acid, and 2 of water. Mr. *Morveau*, in the *Memoirs of Dijon*, for 1782, has shewn, that the calces of copper are determined rather to a blue than a green colour, by a greater proportion of phlogiston,

13. They are analysed in the moist way by solution in acids, and precipitation by the mineral aerated alkali, if they be pure, or by the *Prussian* alkali, if they contain earths. 194 grains of the precipitate formed by the mineral alkali are equivalent to 100 of copper in its metallic state: so also are 350 gr. of the precipitate formed by the *Prussian* alkali, as Mr. *Bergman* has determined: copper also may be precipitated in its metallic
state

state by means of iron, though it is not easy to get it pure, if the nitrous acid be the solvent.

14. I have found that 112 gr. of good iron, precipitate 100 of copper from a saturate and dilute solution of it in the nitrous acid, and 80 gr. of the same iron precipitate, 100 of copper from a saturate and dilute solution of it in the vitriolic acid; so that weighing the iron before and after, the quantity of copper may be estimated by the loss of weight of the iron; but care must be taken that the iron do not remain in the nitrous acid after the copper is precipitated. Experience will point out some other precautions too tedious to be inserted here.

15. If iron be mixed with the ore, it may be separated by long boiling in nitrous acid.

16. In the dry way, after torrefaction, they may be assayed by melting them with $\frac{1}{2}$ or $\frac{3}{4}$ of their weight of borax, and $\frac{1}{4}$ of their weight of pitch. Some loss always attends the black flux. Thus Mr. *Fontana* having assayed 576 gr. of a calciform ore by black flux, obtained but 376 or 380 of copper, yet by distillation he got 408. 11 *Roz.* p. 511.

SPECIES III.

Cupreous Stones.

Analogous to the calciform ores are the cupreous stones, *Turquoise* and *Lapis Armenus*.

17. *Turquoise* is the tooth of an animal penetrated with the blue calx of copper ; it loses its colour when heated ; it is opaque, and of a lamellar texture, and susceptible of a fine polish ; its specific gravity is from 2,5 to 2,908 ; some are of a deep blue, some of a whitish blue, but become of a deeper when heated. This stone is found in *Persia* and *Languedoc*. The copper may be extracted from it by distilled vinegar. According to *Reaumur*, *Mem. Par.* 1715, nitrous acid will not dissolve that of *Persia*, though it will that of *France*, which shews a difference between them.

18. *Lapis Armenus* is another blue stone which does not admit of any polish, and consists of calcareous earth, or gypsum penetrated with the blue calx of copper : hence it sometimes effervesces with acids, and sometimes not, but never gives fire with steel ; it loses its colour when heated,

SPECIES IV.

SPECIES IV.

Mineralized by Sulphur with scarce any Iron.

Vitreous Copper Ore, Kupfer glafs ertz.

19. Its colour is red, brown, blue or violet; it is generally so soft as to be cut with a knife, and as to form, it is sometimes crystallized in regular figures, and sometimes amorphous; it is much more fusible than pure copper; its specific gravity is from 4,81 to 5,338. It is found in the mines of other copper ores, and in lime stone, spar, quartz, mica and clay; it is the richest of all the copper ores, and affords from 80 to 90 per cent. of copper, 10 or 12 of sulphur, with a small proportion of iron; the red ores are the poorest, containing most iron.

20. To analyse this ore, Mr. *Bergman* advises a solution of it in 5 times its weight of concentrated vitriolic acid by ebullition to dryness and the subsequent addition of as much water as will dissolve the vitriol thus formed. This solution he precipitates by a clean bar of iron, and thus obtains the copper in its metallic form. If the solution be contaminated with iron, he re-dissolves thus the copper thus obtained, in the same manner, and so procures a richer solution, which he again precipitates with iron.

21. Dr. *Fordyce*, in the *Philosophical Transactions* for 1780, suggests an improvement, by first dissolving the ore in nitrous acid, and precipitating it by a fixed alkali (if this solution be boiled, any iron it may contain will be precipitated) the precipitate he re-dissolves in vitriolic acid, and precipitates it with iron.

22. The proportion of sulphur may be found by dissolving the ore in dilute aqua regia, as the sulphur will remain undissolved.

SPECIES V.

Mineralized by Sulphur, with 20 or 30 per cent. of iron.

Azure Copper Ore, Kupfer Lazur, Kupfer malm.

23. This differs from the foregoing only in containing more iron; its colour consists in various shades of blue, or reddish blue; it is as hard, and much more brittle; it contains from 40 to 60 per cent. of copper, from 20 to 30 of iron, and the remainder sulphur; the poorer it is in iron, the richer in copper; it has been by many confounded with indurated *mountain blue*.

SPECIES VI.

SPECIES VI.

Mineralized by Sulphur, with a large Proportion of Iron.

Yellow Copper Ore, yellow Pyrites.

24. Its colour is yellow, or yellow mixed with red or green, or variegated like a pigeon's neck ; it is moderately hard, not readily giving fire with steel as other pyrites do ; in its fracture it presents sharp fragments ; it is sometimes found crystalized, and sometimes amorphous ; its specific gravity is about 4.16 ; it occurs both in separate masses and imbedded in stones, and is the commonest of all the copper ores.

25. With respect to its contents, the crystalized sort is the poorest in copper, of which it contains only from 4 to 8 per cent, the remainder is chiefly iron ; it is generally reddish, and is in fact a martial pyrites, with a small proportion of copper ; the greenish yellow contains most sulphur, and from 15 to 20 per cent. of copper ; the pure yellow contains most copper ; namely, from 20 to 30 per cent. its texture is foliated ; these pyritous ores always contain argill, and a little of siliceous earth.

SPECIES VII.

SPECIES VII.

Mineralized by Sulphur and Arsenic, with a little Iron.

Arsenical or grey Copper Ore. Kupfer fahl ertz, Weiss kupfer ertz.

26. This is of a white, grey, or brown colour; it is moderately hard, and very brittle, sometimes crystalized, and often of an indeterminate figure; it is of very difficult fusion, and heavier than the preceding.

27. It contains from 35 to 60 per cent. of copper; the brown is the richest in copper; the white or grey contains most arsenic; it frequently contains silver, and if this exceeds 1 or 2 per cent. it is called *grey silver Ore*.

It is found imbedded in all sorts of stones, and mixed with other copper ores as well as with the ores of other metals.

28. The analysis of these ores in the moist way may be understood from what has been already said. To assay them in the dry way, they should first be pulverized and separated as much as possible from stony and earthy particles, then roasted to separate the sulphur and arsenic, then melted with a mixture of an equal weight of Mr. Tillet's flux, which
consists

consists of 2 parts pounded glass, 1 of calcined borax, and $\frac{1}{4}$ of charcoal: if the ore be poor more borax may be added; black flux is hurtful, as it forms an hepar which holds part of the copper in solution. *Mem. Par.* 1775.

29. Mr. *Margraaf*, in the *Memoirs of Berlin* for 1775, recommends a mixture of equal parts of clay well washed, fluor, and lime-stone, and $\frac{1}{2}$ part of charcoal, with an equal weight of the torrefied ore; the whole to be melted in a porcelain heat. The coal he uses is that left after the distillation of tartar.

SPECIES VIII.

Mineralized by Sulphur and Arsenic, with Zinc and Iron.

Blendose Copper Ore.

30. Mr. *Monnet* says he has met with this ore only at *Catharineberg* in *Bohemia*: it is of a brown colour, of a hard, solid, and compact granular texture; it contains from 18 to 39 per cent. of copper.

31. It is analysed in the liquid way by solution in nitrous acid and precipitation of the copper by iron: the iron and zinc are precipitated

pitated then by the *Prussian* alkali; the precipitate calcined is re-dissolved in nitrous acid, and the solution evaporated to dryness; the iron being thus deplogificated becomes insoluble in nitrous acid; the calx of zinc is re-dissolved in that acid, and again precipitated by the *Prussian* alkali. 100 gr. of that precipitate washed and dried are equivalent to 20 of zinc in its metallic state, and 100 gr. of deplogificated iron are equivalent to 73.5 of iron in its metallic state.

SPECIES IX.

Argillaceous, Shistose, or slaty Copper Ore, Kupfer Schiefer.

32. This ore seems to consist of the vitreous copper ore, intimately combined with shistus, and not barely dispersed through it in visible particles; it is of a brown or black colour, lamellar texture, and very heavy; it affords from 6 to 10 per cent. of copper, and is of difficult fusion, unless lime-stone be added; it contains a little bitumen, calcareous earth and iron, as *shisti* do.

SPECIES X.

Bituminous Copper Ore. Kupfer brand ertz.

33. This is said to be found in *Sweden*; it is a species of coal which gives little or no flame,

Copper.

269

flame, but consumes and leaves ashes, from which copper is extracted.

SPECIES XI.

Copper in a foreign Form.

34. Animal and vegetable substances are sometimes found penetrated with copper.

SPECIES XII.

Mineralized by the Vitriolic or Marine Acids.

35. These are mentioned and described in the second part : in the dry way they are reducible by Mr. Tillet's flux.

CHAP. V.

Iron.

1. Its specific gravity is from 7,6 to 8,00, that of the most dephlogisticated calx of iron, only 6,7. It is soluble in all acids, and the saturate solution precipitable by vegetable astringents of a *black* colour, and by *Prussian* alkali of a *blue* ; in its metallic or slightly dephlogisticated state it is attractable by the magnet ; it is the most difficultly fusible of all metallic substances, except platina and manganese.

SPECIES I.

SPECIES I.

Native.

2. It is now known that native iron exists in many places, the most remarkable mass of this sort is, that discovered in *Siberia*, which weighs 1600 pounds. It is of that species called *redshort* iron, being malleable while cold, but brittle when red hot. *Pallas Reisen*, 3 *Theil*. p. 411.

*Mineralized.**Calciform Ores.*

3. The basis of the calciform ores, is either the black or blackish brown calx of iron, which is in some measure phlogisticated and magnetic, or the red calx of iron, which is more dephlogisticated, and not magnetic before torrefaction.

SPECIES II.

Brown Calx of Iron, mixed with Iron in its metallic State.

*Steel Ore. Stablerz. Ferrum Chalybeatum, Lin.
Minera Ferrinigra. Cronst. §. 212.*

4. Of a dark steel colour, solid, compact, and shining in its fracture; scarcely gives fire with

with steel, gives a black powder, is magnetic, and in some degree malleable when red hot. It affords from 60 to 80 per cent. of good iron. It is found at *Adelfors* and *Danne-mora* in *Sweden*, also in the *Isle of Elbe*, and *North America*.

5. Chrystalized iron ore in an octohœdral or cubic form, *ferrum tessulare*, and *minera ferri crystalizata* of *Wallerius*, belongs to this species, it is somewhat less magnetic, probably because it contains less of metallized iron.

SPECIES III.

Magnet.

6. This differs but little in its appearance from the preceding ore, but has less lustre ; it is either coarse or fine grained, the coarse grained loses its power soonest. It seems to contain a small quantity of sulphur, as it smells of it when red hot. It is probable that it contains more particles of iron in its metallic form, than the preceding ore, but it is often contaminated with a mixture of quartz and argill. It is possible it may contain nickel, for this when purified to a certain degree, acquires the properties of a magnet, 2 *Bergm.* 242. Its constitution, has not as yet been properly examined.

SPECIES

SPECIES IV.

Brown Calx of Iron, combined with Plumbago.

*Black Eisen Glimmer, Schwartz Eisen Rahn
or Eisenman.*

7. This consists of black shining scales, more or less magnetic; Mr. *Rinman* found it to consist of plumbago, and 26 per cent. of iron. *Historia Ferri.* §. 57.

SPECIES V.

Brown Calx of Iron, united with the white Calx of Manganese, and mild Calcareous Earth in various proportions.

*White or Sparry Iron Ore, Weiss Eisen Spath,
Stahlstein.*

8. Its colour when fresh dug is whitish, but by exposure to the air, it first becomes grey, then brown, at last reddish, yellowish, or black. Its shape, either amorphous or rhomboidal, it is frequently transparent, its texture lamellar, scaly, granular, or cellular. Sometimes it assumes a stalactitical form, and sometimes it is found in a powdery state, and is then of a brown blackish colour, is frequently interspersed with quartz and pyrites,

rites, &c. and does not give fire with steel, unless these foreign substances be struck. Its specific gravity is from 3,6 to 3,895, or 4,000 it feebly effervesces with acids, particularly when pounded and heated, affords from 20 to 27 per cent of fixed air. It is scarce ever magnetic before calcination, but if heated, it decrepitates, grows black, becomes magnetic, and loses from 15 to 40 per cent of its weight.

9. 100 Parts of this ore from *Eisenärtz* in *Steria*, afford according to Mr. *Bergman*, 38 of the brown calx of iron, 24 of the white calx of manganese, and 38 of mild calcareous Earth. Another sort from *West Silvertberg* contains 22 of the brown calx of iron, 28 of the white calx of manganese, and 50 of mild calcareous Earth. What quantity of iron and manganese in a reguline state, these quantities of each calx would produce, may be seen by the table inserted at the end of this treatise; the aerial acid is united not only to the Earth, but also to the metallic calces, as appears by its proportion. Many other ores are poorer, and some to such a degree as not to deserve the name of an ore. It is frequently mixed not only with quartz and pyrites, as already mentioned, but also with shoerl, zeolyte, mica or asbestos.

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10. When this ore bears a stalactitical appearance, and is very white, it is called *flos ferri* and *eisen bluth*: this affords 27 per cent. of reguline iron according to Mr. *Rinman*, and consequently 35 of the brown calx.

SPECIES VI.

Magnetic Sand.

11. That of *Virginia*, whose colour is black, is of this sort; its specific gravity is 4,600, and it contains about $\frac{1}{2}$ its weight of iron; but its composition has not yet been discovered.

SPECIES VII.

Red Calx of Iron indurated, and combined with a little Argill, and frequently with Manganese.

Hæmatites. Glasz kopf.

12. It is generally of a red, yellow, purple, or brown colour, of a metallic lustre, and very hard, though seldom so hard as to give fire with steel; when scratched, it shews a red trace; it is not magnetic before torrefaction, but by that heat it becomes black and magnetic; its structure is either solid, granular, scaly, or fibrous; it occurs either in shapeless

shapeless masses, or in a stalactitical form, or even crytallized in regular forms according to *Gmelin*, though Mr. *Delisle* denies it; in some places it forms whole mountains; it affords from 40 to 80 per cent, of iron. According to Mr. *Gerhard* it contains argill, for he extracted alum from it. Mr. *Helm* found it also to contain manganese.

SPECIES VIII.

Hematites in a loose form, mixed with a notable Proportion of Argill.

Hematitical yellow, red and brown Ochres.

13. Ochres are distinguished from clays by containing a larger proportion of martial particles; those that become brown by calcination, and also magnetic, belong to this species; sometimes the ferruginous particles are mixed with argill, and calcareous or muriatic earths, and then these ochres effervesce with acids.

SPECIES IX.

Red Calx of Iron combined with Plumbago.

Red Eisen Glimmer, Eisenrahm and Eisenman.

14. This differs from the black in this, that it is not magnetic before torrefaction.

SPECIES X.

Red Calx of Iron, mixed with a small Proportion of the brown, and indurated.

Torsten.

15. This is of a bright bluish black, or yellowish grey colour, and fibrous texture, shews a red trace when scratched, and is weakly magnetic before calcination. According to Mr. *Rinman* it is less dephlogisticated than hæmatites. *Historia Ferri*, §. 285.

SPECIES XI,

Emery.

16. Emery seems to be a mixture of the red and white calces of iron, with some unknown stony substance, perhaps tripoli; it scarcely yields in hardness to any substance, except diamond; the best sort is of a dark grey colour, but becomes brown, and in great measure magnetic by calcination; other sorts are of a reddish rusty white, or yellowish colour; its specific gravity is from 3,000 to 4,000; it is never used as an iron ore, nor is its proportion of iron well known.

SPECIES

SPECIES XII.

Red Calx of Iron united to Siderite.

Grey Iron Ore.

17. This has a shining metallic appearance, and commonly gives fire with steel ; it is not in the least magnetic, and when scratched shews a red trace ; it yields from 40 to 66 per cent. of *coldshort* iron.

18. The ore called by the *Swedes* *su fierne malm*, or *minera pleiadum*, is a mixture of the grey iron ore, with rhombic nodules of that described in N^o 5.

SPECIES XIII.

Argillaceous Iron Ores.

19. Of these we may distinguish two principal varieties, namely, those found in mountains and high lands, and those found in swampy grounds, or low lands overflowed with water ; both are destitute of metallic lustre, but very weighty, and some of them when dry absorb water like clays.

L VARIETY.

*High land Argillaceous Ores.**Minera ferri Ochracea.*

20. These are either yellow, red, brown, or greyish, indurated and friable, or loose and powdery, or in grains; they consist chiefly of the red or yellow calx of iron, or of the grey iron ore, or *torsten* in a loose form, mixed with argill or clay, and consequently often contain manganese, or siderite, and some, particularly in *France*, and the neighbourhood of *Liege*, are said to contain the calx of zinc. Hence there are many varieties of them, and their yield of iron, as well as its qualities, are very different: they do not effervesce with acids, (unless calcareous or muriatic earth be casually mixed with them,) and are difficultly soluble in them; the most soluble are the best; they never obey the magnet before calcination, and rarely after it.

21. Horn-stone over-loaded with iron belongs to this species.

22. Mr. *Rinman* mentions a *white* iron ore found in *Kent*, mixed with clay or marl, which affords 47 per cent. of brittle iron,
and

and is scarcely soluble in acids. *Hist. ferri*,
P. 733.

II. VARIETY.

Swampey Argillaceous Ores.

*Minera ferri Lacustris vel subaquea. Mine
de fer Limoneuse.*

23. When dry, this ore is friable, and brown, or brownish black, and appears either in lumps of an irregular shape, or in round balls porous or solid, or in flat round pieces, or in grains, and sometimes in slender triangular prisms parallel to each other, and very brittle. It is mixed with argill and extractive matter, and becomes magnetic after calcination, by which operation it loses about $\frac{1}{4}$ of its weight, and the greater part of what is thus volatilized is water, the remainder aerial acid and volatil alkali. The crude ore affords about 36 per cent. of regulus, and after calcination about 50 per cent. it is the chief matrix of siderite, and the iron procured from it is *coldshort*, at least in *Sweden*. The iron of *Husaby*, of which Mr. *Bergman* treats in his analysis of iron, is drawn from this ore. Mr. *Hielm* has found some sorts of it to contain 28 per cent. of manganese.

SPECIES XIV.

Red Calcareous Iron Ore.

24. This is found in a loose form in many parts of *England*; it effervesces strongly with acids, and is used as a pigment.

SPECIES XV.

Siliceous Iron Ore.

25. Besides jasper, garnet and trapp overloaded with iron, there is found, principally in *France*, a black, heavy, unmagnetic sand, of the siliceous kind, which is said to contain iron and zinc in great quantity.

26. Baron *Born*, in his letters from *Hungary*, mentions a blue crystalized iron ore, which he says is a shoerl overloaded with iron.

SPECIES XVI.

Muriatic Iron Ore.

27. Serpentine overloaded with iron forms this species, but it is seldom worked.

SPECIES XVII.

Martial Calamine.

28. Calamine is properly an ore of zinc, but sometimes it contains so large a proportion

tion of iron as to be worked with a view of obtaining this metal ; it consists of a mixture of quartz and argill, with the calces of iron and zinc ; its colour is yellow, red, or brown, and it is moderately hard.

SPECIES XVIII.

Mineralized by Sulphur.

Martial Pyrites.

29. These are stony concretions of sulphur, clay, and calx of iron, so hard as to give fire with steel. There are two principal varieties of them.

I. VARIETY.

Pale yellow Pyrites.

30. This has been already described among the ores of alum.

II. VARIETY.

Brown or reddish brown Pyrites. Minera ferri hepatica, Wasser kiefs.

31. It is generally of a spherical shape, or crystalized in cubic, rhomboidal, or other polyhædral forms, and is devoid of metallic lustre ; it difficultly gives fire with steel, and contains very little sulphur, but much more iron.

iron than the yellow pyrites, and not unfrequently a mixture of calcareous Earth. It is sometimes magnetic before, and always after calcination. It is incapable of vitriolization. The iron it affords is brittle.

SPECIES XIX.

Mineralized by Sulphur and Arsenic.

*White, Grey, or Bluish grey Pyrites, Marcassite
Rausch gelb kiefs, Gift kiefs, Arsenic Stein.*

32. It is found either in solid compact masses of a moderate size, or in grains, it gives fire with steel; when burnt, it affords a blue flame, and an arsenical smell, and by distillation, orpiment, or realgar, it is not magnetic, either before or after calcination, it contains much more of arsenic than of sulphur. It is analysed by digestion in marine acid, to which the nitrous is gradually added, otherwise the sulphur would be destroyed. See N^o 34.

SPECIES. XX.

Mineralized by Arsenic singly.

Mispickel. Speiss of the Bohemians.

33. Its colour is generally of a bright white, resembling a mixture of silver and tin, rarely variegated

variegated like a pidgeons neck, and is not easily altered by exposure to the air. Its form either granular, cuspidated, cuneiform, prismatic or rhomboidal. It is magnetic neither before nor after calcination, is soluble in acids, affords arsenic by distillation, in the proportion of 30 or 40 per cent, and sometimes contains a small proportion of copper and silver. It is frequently mixed with other metallic ores, and often found in indurated clay, quartz, spar, shoerl, &c.

34. When iron contains less than $\frac{1}{18}$ of arsenic, it is magnetic, *Scheff.* §. 300, therefore if the calcination be pushed so far, the iron will remain magnetic. It may be analysed by solution in the marine acid, which will take up the iron and leave the arsenic, or by solution in aqua regia, which will take up both, but water being added, will precipitate the arsenic and leave the iron. The silver will remain in the form of horn silver, and the copper may be separated by the methods already mentioned.

SPECIES XXI.

Combustible Iron Ore.

35. Of this kind Mr. *Cronsted* mentions two varieties, one, of which the greater part is

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is volatil, in a strong heat long continued, and seems to contain iron, plumbago, and coal intimately mixed. The other burns with a languid flame, loses about $\frac{1}{5}$ of its weight, resembles pit-coal, but is somewhat harder, and yields about 30 per cent of iron.

SPECIES XXII.

Mineralized by the Vitriolic Acid.

36. This has been mentioned under the head of saline substances.

Uncertain Mineralizations.

SPECIES XXIII.

Iron Blende.

37. This is said by Mr. Monnet to be a stone of a grey iron colour, formed of diverging laminæ, of great hardness and a metallic appearance, but insoluble in acids, and infusible in the strongest fire, *Mineral.*

356. Sometimes this stone contains arsenic, in this case it blackens by exposure to the air.

SPECIES XXIV.

Wolfram.

38. This stone which is generally found in tin mines, is of a black or brown shining colour,

colour, of a radiated or foliated texture, of a moderate hardness, and sometimes so brittle, as to be easily broken between the fingers, but very weighty since its specific gravity is 7,119; when scratched it shews a red trace, which distinguishes it from tungsten. It is scarcely soluble in acids, and of very difficult fusion. According to *Lehman*, it consists of siliceous Earth, calx of iron, and a small proportion of that of tin, *Chym. Schrift.* 356, and from his experiments, I am inclined to think it contains manganese.

SPECIES XXV.

Native Prussian Blue.

39. It consists of clay mixed with iron, and some unknown tinging substance, generally found in swampy grounds or bogs. It is at first white but when exposed to the air, it becomes either of a light or deep blue. When heated, it turns greenish, and emits a slight flame, and then becomes red and magnetic, it is soluble both in acids and alkalis, but the latter precipitate it from the former, and the former from the latter; the precipitate is at first greenish, but gradually assumes a white hue, but recovers its blue tinge if it be steeped in vegetable astringents, *Bergm. Sciagr.* §. 206. *Phil. Trans.*

1768. The Earth of *Beuthnitz* in *Silesia*, mentioned in the *Memoirs of Berlin* for the year 1757, seems to belong to this species, it contains about $\frac{1}{4}$ of its weight of iron.

SPECIES XXVI.

Green Earth of Verona and Normandy.

Terre Verte.

40. This is used as a pigment, and contains iron in some unknown state, mixed with clay, and sometimes with chalk and pyrites; allum and selenite are also accidentally found with it. It is difficultly soluble in acids, is not magnetic before calcination, and becomes of a coffee colour when heated. It is said to afford about 40 per cent of iron. If iron be precipitated from vinegar, by the arsenical acid, the precipitate will be green, 36 *Mem. Stock.* and it will preserve its colour though exposed to the air. Iron precipitated from the marine acid by lime water, is frequently green, and green fluors are known to derive their colour from this metal. The molybdenous acid gives also a green colour to iron, but this fades.

*Of the Analysis and Essay of Iron Ores.**In the moist Way.*

41. The general method of analysing in the moist way the *calciform ores*, which do not contain much earth or stony matter, is, after reducing them to a subtil powder, to dissolve them in the marine acid, and precipitate them by the *Prussian* alkali; the quantity of alkali used discovers that of iron in its metallic state, which the ore would afford, as already mentioned in the analysis of earths, or the precipitate washed and dried may be weighed; its weight divided by 6 (subtracting 4 per cent. for the iron already contained in the alkali) gives the quantity of iron in its metallic state which the ore contains.

But if the iron be united to any considerable proportion of zinc or manganese, its estimation by the above methods is not sufficiently accurate; therefore the *Prussian* blue must be calcined to redness, and the calx treated with dephlogisticated nitrous acid, which will then take up only the calx of zinc; when this is separated, the calx should be again treated either with nitrous acid, with the addition of sugar, or still better, with the acetous acid, either of which will separate the manganese, if any; the remaining calx
of

of iron may then be dissolved by the marine, and precipitated by the mineral alkali, or it may be further calcined, and then weighed. The annexed tables shew the correspondence betwixt the weight of the calx, or the precipitates with that of iron in its metallic state. See also Chap. 15. N^o 18.

42. To analyse the *white calcareous iron ore*, it should be first calcined to find the weight of the fixed air and water, then thrown into dephlogisticated nitrous acid, and shaken for a few minutes until the menstruum begins to acquire a yellow colour; it will then contain the calcareous earth only, which may be precipitated by the mineral alkali, and weighed; the residuum well calcined may be treated with the acetous acid as above.

43. According to Mr. *Rinman*, the contents of this ore may be conjectured very nearly from its specific gravity; for as 80 is to 100, so is the specific gravity of this ore to its contents per cent.

44. The pyritous, argillaceous and stony ores are analysed by solution in marine acid, to which, if necessary, a little of the nitrous may be added: this digestion should be continued as long as the menstruum acquires
a yellow

a yellow colour ; coction may be requisite at the end.

45. Many ores, which are difficultly soluble before calcination, become easily soluble after they are calcined.

46. To discover siderite in an ore, it should be dissolved in dilute vitriolic acid ; the solution, after standing some hours, will deposit a white calx, if siderite be contained in it.

In the dry Way.

47. Mr. *Morveau* recommends the following flux for all iron ores : 8 parts pulverised glass, 1 of calcined borax, and $\frac{1}{2}$ of charcoal, well mixed ; of this flux he takes two parts, or, if the ore be very poor, 3 parts, and 1 of the ore, and places them in a crucible, lined with a mixture of a little clay, and pounded charcoal $\frac{1}{8}$ of an inch thick, to which a cover is luted : this he places in a smith's forge, and urges it with a strong heat for half an hour ; to find whether the ore requires calcination, he institutes this trial with equal weights of the ore calcined and uncalcined, and compares the results ; the weight of the ore should not exceed 60 grains.

48. Mr. *Bergman* essays the white sparry iron ore by placing it in a crucible lined with char-

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coal

coal $\frac{1}{2}$ an inch thick at bottom, and $\frac{1}{8}$ on the sides, simply covering it with calcined borax, luting on this another crucible, which he also exposes to the heat of a smith's forge.

49. Argillaceous and siliceous iron ores may be essayed in the following manner: take of the ore 4 parts, quick lime 1,25, fluor spar 1,25, powdered charcoal 1, decrepitated common salt 4; the whole, being well mixed, place in a crucible lined with charcoal, to which a cover should be luted, and the lute being dry, commit it to a smith's forge, giving a moderate heat for $\frac{1}{4}$ of an hour, and the strongest for the remainder of the hour; if the lime be slacked, double the quantity must be used. 6 *Crell. Nev. Entdeck.*

50. Calcareous ores may be treated in the same manner, except that instead of quick lime double the quantity of fluor should be used.

51. Pyritous ores are also essayed nearly in the same manner; the proportions being 4 parts of the ore previously roasted, 2 of quick lime, 2 of fluor, $1\frac{1}{2}$ of charcoal, and 4 of decrepitated common salt. *Ibid.*

52. Iron ores, which, though at first bright in their fracture, soon grow black by exposure to the air, contain much manganese.

53. To

53. To find whether iron or its ore contains manganese, let a small quantity of it be heated white in a crucible, and on this project 5 times its weight of purified nitre, taking care that no coal or ashes should get into the crucible: when all is cold, the upper part of the crucible will be covered with a greenish or bluish crust, if the iron contain manganese. 3 *Bergm.* 66. When the solution of iron in the marine acid is of a red colour, this also denotes the presence of manganese, though that colour soon changes to a yellow, by extracting phlogiston from the martial part.

54. Mr. *Bergman* gives also a method of finding whether the ore affords coldshort or redshort iron. He melts the regulus obtained from the ore with $\frac{1}{4}$ of its weight of good malleable iron in a crucible lined with charcoal, and well covered. If the regulus thus obtained be brittle when cold, the ore affords coldshort iron, or if it cracks under the hammer in a white heat, it is redshort. 3 *Bergm.* 46.

C H A P. VI.

Tin.

1. The colour of tin is too well known to need being described; its specific gravity is
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from 7 to 7,45; the lightest is the purest; it melts the most readily of all metals; it is easily dissolved in spirit of salt or aqua regia, and its solution is precipitated blue or purple by that of gold.

SPECIES I.

Native.

2. The existence of native tin has long been questioned, but it has undoubtedly been found some years ago in *Cornwall* in the form of thin flexible laminæ issuing out of a matrix of quartz, or regularly crystalized. *Phil. Trans.* 1766. p. 37. and Mr. *Quist*, a very competent judge, attests its purity in the *Memoirs of Stockholm* for the same year.

3. To ascertain its purity, Mr. *Bergman* advises dephlogisticating it by the nitrous acid. 140 gr. of this calx washed and dried are equivalent to 100 of tin in its metallic form; the solution will take up the copper, and a small proportion of iron which the tin may contain, and these again may be separated by boiling; if there be any arsenic, it will be found in the washings.

SPECIES

SPECIES II.

Calciform Ores.

4. These ores are remarkable for their great weight, their specific gravity being from 5,955 to 6,75: they may be reduced to 4 Varieties.

I. VARIETY.

Tin Spar, white Tin Ore.

5. It is generally of a whitish or grey colour, sometimes greenish or yellowish, semi-transparent and crystalized in a pyramidical form, or irregularly: it was formerly thought to contain arsenic; but Mr. *Margraaf* found it the purest of all tin ores, 1 *Margr.* 188, 189, though it is said to contain sometimes a mixture of calcareous earth; its specific gravity is 6,007.

II. VARIETY.

Opake, brown or black Tin Ore.

6. This is also crystalized and imbedded in a stony matrix of quartz, fluor or mica, or mixed with white or yellow pyrites, or in ores of lead or zinc, cobalt, wismuth or iron; when these crystals are large, they are called by the Germans *zingraupen*, and when small

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zin zwitter; the black are reckoned the richest, and afford about 80 per cent. of tin; they all contain a mixture of iron.

7. The ore called *weiss zingraupen* is that which was mentioned under the calcareous genus by the name of *tungsten*; it contains no tin. When any arsenic is found in tin, it proceeds from the matrix, for tin itself is never mineralized by it; and for the same reason zinc is sometimes found in tin.

8. The specific gravity of this ore is 6,75.
Mem. Stock. 1778, p. 321.

III. VARIETY.

Reddish or reddish yellow Tin Ore, Garnet Tin Ore.

9. This consists of small crystals semi-transparent or opaque, and sometimes it is found of a spherical form, striated, and resembling hæmatites or zeolyte; its specific gravity is from 5 to 5,8; it contains more of iron than of tin.

IV. VARIETY.

Tin Stone, Zinstein of the Germans, Tinberg of the Swedes.

10. The preceding varieties consist for the most part of metallic particles; the present, chiefly

chiefly of stones or sands of different sorts, which contain calx of tin invisibly diffeminated through them ; their specific gravity, when the proportion of tin is of any importance, is considerable ; they may be of any colour, blue, grey, black and brown are the commonest ; they are called *Lodestones*.

12. Tin ores are very scarce, not being hitherto found in any considerable quantity, except in the *East Indies*, *Cornwall*, *Bohemia* and *Saxony*.

13. It is remarkable that tin has not as yet been found in any stones of the calcareous genus, except fluors, but only in those of the siliceous or agillaceous kind.

SPECIES III.

Mineralized by Sulphur.

14. This was lately discovered by Mr. *Bergman* among some minerals which he received from *Siberia*. He observed two sorts of it analogous to the two artificial combinations of tin with sulphur ; one nearly of the colour of zinc, and of a fibrous texture, which contained about twenty per cent. of sulphur, and the remainder tin ; the other enveloped the former like a crust, resembled *aurum musivum*, and contained about 40 per cent. of

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fulphur

sulphur, a small proportion of copper, and the remainder tin. *Mem. Stock.* 1781, p. 328.

15. To assay tin ores in the *liquid way* has hitherto been thought impracticable; however, Mr. *Bergman* has devised the following method, which is generally successful. Let the tin ore, well separated from its stony matrix by washing, and reduced to the most subtile powder, be digested in concentrated oil of vitriol in a strong heat for several hours, then when cool add a small quantity of concentrated marine acid, and suffer it to stand for one or two hours; then add water, and when the solution is clear pour it off, and precipitate it by fixed mineral alkali. 131 gr. of this precipitate washed and dried are equivalent to 100 of tin in its reguline state, if the precipitate consists of pure tin; but if it contains copper or iron, it should be calcined for one hour in a red heat, and then digested in nitrous acid, which will take up the copper, and afterwards in marine acid, which will separate the iron.

16. In the *dry way*, these ores, after pulverization and separation of the stony matter by washing, are to be melted with a mixture of double their weight of a flux, consisting of equal parts of pitch and calcined borax, in a crucible

crucible lined with charcoal, and to which a cover is luted; fusion should be speedily procured.

17. Mr. *Bergman* recommends a mixture of one part of the ore with two of tartar, 1 of black flux, and $\frac{1}{2}$ part of rosin: this is to be divided into three parts, and each successively projected into a crucible heated white, and immediately covered after the foregoing portion ceases to flame; the whole operation takes up but 7 minutes or less. *Sbeff.* §. 304.

CHAP. VII.

Lead.

1. This metal is sufficiently distinguishable by its colour, which is well known, its specific gravity, which reaches from 11,3 to 11,479, its great softness and easy fusibility. It is more or less soluble in all acids, and particularly in the nitrous, and all its solutions have a sweetish taste, it is precipitable from the nitrous by the vitriolic or marine, and from the marine also, by the vitriolic.

SPECIES I.

Native Lead.

2. It is said to have been found in *Monmouthshire*

mouthshire in small pieces, *Phil. Trans.* 1772, p. 20, also in the *Vivarais*, *Gensanne hist. Languedoc*, vol. 3. p. 208. *Henckel* also mentions it in his *Flora Saturnifans*. If it contains copper, this latter may be detected by a plate of iron immersed in its solution in nitrous acid, and the presence of silver, if any be contained in it, will be discovered by a plate of copper.

SPECIES II.

Mineralized by the Aerial Acid.

Calciform Ores.

3. Of these we may distinguish 5 varieties, all easily soluble in nitrous acid, and with effervescence if heat be used, and also in expressed oils; all contain a little iron, but never silver.

I. VARIETY.

White, Lead Spar, Lead Ochre, Native Ceruss.

4. *Lead Spar* is sometimes transparent, but generally opaque, and crystalised in regular forms, of a laminar or striated texture. *Lead ochre*, or *native ceruss* is the same substance, but in a loose form, or indurated and shapeless; sometimes it is found in a silky form. Both contain a little iron, and sometimes calcareous.

calcareous earth and argill. *Jacquin's Miscell.* 157. 3 *Roz.* 348. both grow red or yellowish when sufficiently heated. They effervesce with acids, and afford from 60 to 80 or 90 per cent. of lead; both are found in *Brittany, Lorrain, Germany, and England.*

II. VARIETY.

Red, Brown, or Yellow.

5. This is also found either regularly crystalized, or in shapeless masses, or in powder. It differs from the former only by containing more iron. That in powder contains a mixture of clay. It affords about 70 or 80 per cent. of lead.

III. VARIETY.

Green.

6. Either crystalized in needles as in *Brittany*, or in a loose powder as in *Saxony*, but mostly adhering to, or investing quartz. It owes its colour to iron, and seldom contains copper. 3 *Lin. Von Gmel.* 225. 10 *Roz.* 375.

IV. VARIETY.

Bluish.

7. This is also sometimes crystalized, sometimes

times amorphous. It owes its colour to a mixture of copper.

V. VARIETY.

Black.

8. The most uncommon of all, and occurs either crystalized, or of an indeterminate form.

9. These ores, when freed as much as possible from earthy matter, are assayed in the moist way, by solution in spirit of nitre. The solution being boiled, deposits the calx of iron. If the lead be then precipitated by an aerated mineral alkali, 132 gr. of the precipitate, will denote 100 of lead in its metallic state. If the ore contains copper, it may be separated by digesting the calx in volatil alkali; if it be suspected to contain silver and copper, then, after the separation of the copper, the calx should be redissolved in nitrous acid, and both the lead and silver precipitated by the marine acid; the marine salt of lead is redissoluble in 30 times its weight of boiling water, but that of silver will remain undissolved, or that of silver may be separated by caustic volatile alkali.

10. In the dry way, these ores are reducible by the simple addition of phlogiston and fusion.

SPECIES

SPECIES III.

Mineralized by the Vitriolic acid.

11. According to Mr. *Monnet*, this sometimes occurs in the form of a white ponderous calx, soluble in 16 or 18 times its weight of water. It does not effervesce, nor is it soluble in other acids; it may be reduced by laying it on a burning coal. It originates from the spontaneous decomposition of sulphurated lead ores. *Mon. Mineral.* 371. According to Dr. *Withering*, it is found in great quantity in the island of *Anglesey*, but united to iron, and not reducible by the blow pipe or charcoal, he promises an exact analysis of it, this is of a yellow colour, and mixed with clay.

SPECIES IV.

Mineralized by the Phosphoric acid.

12. This was lately discovered by Mr. *Gahn*; it is of a greenish colour, by reason of a mixture of iron; it does not effervesce with acids.

To assay it, a solution of it in nitrous acid must be had, with the assistance of heat. From this solution, the lead is to be precipitated by the acid of vitriol. 137 gr. of this precipitate, washed and dried, are equivalent
to

to 100 of lead in its metallic state. The decanted liquor evaporated to dryness, affords the phosphoric acid.

SPECIES V.

Mineralized by Sulphur, with Silver and a little Iron.

Galena, Potter's Ore, Bley Glanz, Bley Schweif, of the Germans.

13. It is the commonest of all lead ores, of a bluish dark lead colour, formed of cubes of a moderate size, or in grains of a cubic figure, whose corners have been cut off; its texture is lamellar, and its hardness variable; the hardest sort containing a greater mixture of iron or quartz; that in grains is thought to be the richest in silver; but the richest contains only about 1 or 1.5 per cent. that is, 12 or 18 ounces per quintal, the poorest about 60 gr. Ores that yield about $\frac{1}{2}$ an ounce of silver per quintal, are barely worth the cost of extracting it; the proportion of sulphur to lead in this ore is also variable within the limits of 15 and 25 per cent. that which contains least is called *Bley Schweif*, and is in some degree malleable. The proportion of lead is from 85 to 60 per cent. by reason of an accidental mixture of quartz, that of iron

Lead.

is generally very small. Dr. *Watson* remarks, that the ores which are poorest in lead, are often the richest in silver. Mr *Monnet* asserted, that sulphurated lead ores are insoluble in nitrous acid, but Dr. *Watson* has shewn that dilute nitrous acid dissolves them completely. 3 *Wats.* 228. The specific gravity of Galena, is from 7,000 to 7,780; when melted it yields a yellow slag.

14. To analyse this ore in the moist way, let it be dissolved by boiling in the dilute nitrous acid, the sulphur and insoluble stony parts and calx of iron will remain undissolved; the iron may be afterwards separated by digestion in marine acid, and the sulphur by digestion in caustic fixed alkali, the residuum weighed before and after will shew the proportion of each.

15. The nitrous solution will contain the lead and silver; this solution should be precipitated by the mineral fixed alkali, and the precipitate washed in cold water, dried and weighed. After weighing it should again be digested in caustic volatil alkali, which will dissolve and take up only the calx of silver, the residuum being again dried and weighed, gives the proportion of the calx of lead, of which 132 gr. are equivalent to 100 of lead in its metallic state; and the difference between the
weight

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weight of the precipitate, before and after the application of the volatil alkali, gives the quantity of the calx of silver, of which 129 gr. are equivalent to 100 of silver in its metallic form.

16. If the ore contains any soluble matrix, which very seldom happens, it should first be separated by boiling in distilled vinegar. 2 *Bergm.* 424.

17. In the dry way this ore may be assayed by melting it with $\frac{1}{7}$ of its weight of filings of iron.

SPECIES VI.

Mineralized by Sulphur, with Silver and Regulus of Antimony.

Antimonial Lead Ore, Sproterz, Stripmalm.

18. Its colour is the same as that of Galena, but its texture is different, being radiated, filamentous, or striated; when heated it yields a white smoke; it affords from 40 to 50 per cent. of lead, and from $\frac{1}{2}$ an ounce to 2 ounces of silver per quintal.

It is assayed in the *liquid way*, by solution in concentrated spirit of nitre, which dephlogisticates the regulus, and leaves it in the form

form of a calx. 138 gr. of this calx are equivalent to 100 of the regulus. Or still better, by solution in spirit of salt which dissolves both the lead and regulus, and leaves the sulphur and stony matter which are separable, as shewn in N^o 14. If water be poured on the solution, the calx of antimony will be separated.

SPECIES VII.

Mineralized by Sulphur, with Silver and a large Proportion of Iron.

Pyritous Lead Ore.

20. This is of a brown or yellowish colour, of an oblong or stalactitical form, friable, and of a lamellar, striated or loose texture; it affords at most 18 or 20 per cent. of lead, which flows by barely heating it, as the iron detains the sulphur; it is no more than a mixture of galena with the brown pyrites, Chap. 5. N^o 31.

SPECIES VIII.

Mineralized by Sulphur and Arsenic, with Silver.

Red Lead Spar.

21. Lately discovered in *Siberia*; externally it is of a pale and internally of a deep
X red,

red, and for the most part crystalized in rhomboidal paralellipeds, or irregular pyramids. According to *Lehman* it contains sulphur, arsenic, and about 34 per cent. of lead, and according to Mr. *Pallas* also silver. *Pallas Reise. 2 Theil. p. 274.*

SPECIES IX.

Stony or sandy Lead Ore.

22. This consists either of the calciform lead ores, or galena, intimately mixed and diffused through stones or earths chiefly of the calcareous kind.

23. It is analysed in the *moist way* in the manner already described, and in the *dry way*, if the matrix be calcareous, by adding the fluor spar, or if siliceous, the black flux with a little iron.

24. Ores of lead are most frequently found among stones of the calcareous or barytic genus.

C H A P. VIII.

Mercury.

1. It were superfluous to mention its less obvious characters, as its liquidity alone sufficiently

ficiently distinguishes it from all other metallic substances.

SPECIES I.

Native.

2. Native mercury has frequently been found in the mines of *Idria*, *Friuli*, *Lower Austria*, *Deuxponts*, &c. flowing from a shistose or quartz matrix, and probably mixed with some other metal, as its globules are not perfectly spherical. In *Sweden* and *Germany* it has been found united to silver in the form of a somewhat hard and brittle amalgam. *Mon. Mineral.* 387. 3 *Lin. von Gmel.* 41. It has also been observed visibly diffused through masses of clay, or stone of a white, red, or blue colour and great weight, in *Spain* and *Idria*, and in *Sicily* in beds of chalk. *Borch Sicil. Mineral.* p. 508.

3. To examine its purity in the moist way, Mr. *Bergman* recommends solution in the nitrous acid; for, as he well remarks, the metals it is most likely to be mixed with are gold, silver and bismuth, as they are most frequently found native: in this solution, gold, if any be contained in the mercury, will remain undissolved; bismuth may be separated by the affusion of water, but the silver and

mercury will remain, and both should be precipitated by the marine acid; the precipitate washed in cold water and dried should be weighed, and then digested in hot water, the marine mercury will be dissolved; the residuum, containing only the marine silver, should again be washed, dried and weighed; the difference between the former and present weight gives the quantity of marine mercury, and the metallic contents of each may be deduced by the rule of proportion from the 2d table.

SPECIES II.

Mineralized by the aerial Acid.

Native precipitate per se or Calx of Mercury.

4. This is said to have been lately found in *Idria* in hard compact masses of a brownish red colour, and granular texture, mixed with some globules of native mercury. By distillation it is recovered in its running form. 100 parts of it afford 91 of running mercury. *Roz. Jan. 1784, p. 61.*

SPECIES III.

Mineralized by the Vitriolic and Marine Acids.

Vitriol and Marine Salt of Mercury.

5. Mr. *Woulfe* first discovered these salts at *Obermoschel*, in the dutchy of *Deuxponts*:
they

they have a spar-like appearance, and are either bright and white, or yellow or black, mixed with cinnabar in a stony matrix; these well mixed with $\frac{2}{3}$ of their weight of vegetable alkali, afforded him cubic and octagonal crystals, that is, salt of silvius and tartar vitriol. *Phil. Trans.* 1776. The marine salt of mercury is in the state of sublimate corrosive.

6. Mr. *Bergman's* ingenious and truly scientific method of discovering the proportion of these salts is nearly as follows: First, by trituration and digestion in marine acid he expells the vitriolic, the mercury uniting preferably with the former of these acids; the whole is then dissolved in a sufficient quantity of hot water; into this solution he drops that of marine baroselenite until no further precipitation is perceived; the true or vitriolic baroselenite thus formed, being washed and dried, contains 13 per cent. of real vitriolic acid: now vitriol of mercury contains 19 per cent. of real acid. Hence the weight of the former being found, that of the latter will easily be known; for supposing the weight of the baroselenite to be 100 gr. then it will contain 13 of vitriolic acid; and since 19 of vitriolic acid go to 100 gr. of vitriol of mercury, 13 will go to 68,4; then if the weight of the vitriol of mercury be

X 3

subtracted

subtracted from that of the whole of the ore, the remainder gives the weight of the marine salt of mercury, and this being sublimate corrosive, 100 gr. of it will contain 77 of mercury, and so in proportion.

SPECIES IV.

Mineralized by Sulphur.

Native Cinnabar.

7. This is of different shades, from a yellowish to a deep red, and is found either pure in hard, friable masses, either shapeless or crystalized in cubes, and sometimes transparent, or intermixed with clay or stone, or interspersed through the ores of other metals, particularly those of silver or copper, or martial pyrites; its texture is either radiated, striated, scaly or granular. 100 parts of cinnabar contain about 80 of mercury, and 20 of sulphur; artificial cinnabar contains a little more sulphur, and hence its colour is darker; its specific gravity is about 7,000; it sublimes in close vessels, and in open, it is decomposed and volatilized when sufficiently heated; it is insoluble in the nitrous and vitriolic acids; it is sometimes contained in very heavy red or brownish red stones or sand.

8. To analyse it in the moist way, its stony matrix

matrix should first be dissolved in nitrous acid, and the cinnabar being disengaged should be boiled in 8 or 10 times its weight of aqua regia, composed of 3 parts nitrous and 1 of marine acid; the mercury may then be precipitated from the solution in its running form by zinc.

9. In the dry way the mercury is obtained in its running form by distilling the cinnabar with $\frac{1}{3}$ of its weight of filings of iron, or even without iron, if the matrix of the cinnabar be calcareous.

SPECIES V.

Mineralized by Sulphur with Copper.

Black Ore of Mercury.

10. According to *Cronsted* and *Linneus* this ore is of a blackish grey colour, glassy texture, and decrepitates strongly when heated; the cinnabar is volatilized, and the copper remains, and may be distinguished by the usual tests.

SPECIES VI.

Pyritous Mercurial Ore.

11. Mr. *Monnet* relates, that he found in *Dauphiné* a grey or whitish friable substance,

100 parts of which afforded 1 of mercury, $\frac{1}{2}$ of silver, and the remainder iron, cobalt, sulphur and arsenic. *Mineralog.* p. 392.

12. Cinnabar mixed with arsenic or realgar is said to be found in *Japan*. 3 *Lin. von Gmelin*, p. 65. - At *Morsfeld*, cinnabar and the white calx of arsenic present themselves in the same rock. *Ibid.*

C H A P. IX.

Zinc.

1. Zinc is the most malleable of all the semi-metals; its colour is nearly the same as that of lead; its specific gravity is from 6,9 to 7,24; it is soluble in all acids, and its solution is colourless; it melts at a lower heat than silver or copper, but a higher than lead or tin, and at the same time inflames and sublimes, forming a light white calx, called flowers of zinc, which are very fixed in fire, and soluble in acids.

SPECIES I.

Native.

2. This has not as yet been observed; that mentioned by *Bomare* appears to have been produced by art,

Mineralized.

Mineralized.

3. All the ores of zinc tinge plates of copper when stratified with them and charcoal, only the sulphureous require previous torrefaction.

SPECIES II.

Mineralized by the aerial Acid.

Calcsiform Ores.

Of these there are 4 Varieties.

I. VARIETY.

Pure Calx of Zinc, Vitreous Zinc Ore, Zinc Spar.

4. Of a whitish, grey, bluish grey or yellowish colour, and of a hardness generally sufficient to strike fire with steel; in its fracture it resembles quartz, amorphous, stalactitical or crystalized in groups, and weighty; by calcination it loses $\frac{1}{3}$ of its weight, without emitting a sulphureous or arsenical smell, and is infusible in the strongest heat either singly or with mineral alkali, but easily fusible with borax or microcosmic salt. In the mineral acids it is soluble with effervescence, and with the vitriolic affords vitriol of zinc. 100 gr. of this ore contains about

65 of the calx of zinc, 28 of aerial acid, 6 of water, and 1 of iron, and sometimes a little of filex. 2 *Bergm. De Min. Zinci.*

5. *Note*, Mr. *Bergman* suspects the substance called zinc spar by Baron *Born* to be a different substance. Mr. *Bindheim* found it insoluble in acids before calcination, and in the dry way infusible with the three usual fluxes, but after calcination it becomes soluble in acids. 4. *Berlin Schrift.* 399.

II. VARIETY.

Mixed with a notable Proportion of Iron.

Tutenago.

6. Mr. *Engestrom*, in the *Memoirs of Stockholm* for the year 1775, has given us an analysis of an ore of this sort from *China*; it was of a white colour, interspersed with red streaks of calx of iron, and so brittle as to be easily broken betwixt the fingers; in the dry way it exhibited the same appearances as the former Variety, except that it lost no part of its weight; it was soluble in the mineral acids, particularly with the assistance of heat, and with the vitriolic afforded vitriol both of zinc and iron; the quantity of fixed air was so small as to be absorbed by the solution; it contained in various specimens from 60 to 90 per

per cent. of zinc; the remainder was iron and a small proportion of argill. Mr. *Bindheim* also discovered this Variety in *Germany*, and found it to consist of zinc, a little iron and filex. 4 *Berl. Schrift.* 400.

III. VARIETY.

Mixed with Iron and Clay in various Proportions.

Calamine.

7. Its colour is white, grey, yellow, brown or red, not so brittle as the 2d Variety, and of various degrees of hardness, though scarce ever so hard as to strike fire with steel; its texture equable or cellular, and its form either amorphous, crystalized or stalactitical; when calcined it loses no part of its weight, except it be mixed with charcoal, and then flowers of zinc sublime; it is soluble in acids, and with the vitriolic affords vitriol of iron as well as of zinc, which shews the iron it contains is not much dephlogisticated. The specific gravity of the best sort, that is, the grey, is 5,000: 100 parts of this afforded Mr. *Bergman* 84 of calx of zinc, 3 of iron, 1 of argill, and 12 of filex; but in other specimens these proportions are very different; some ores are so poor as not to contain above
4 per

4 per cent. of calx of zinc; a good ore should afford at least 30 per cent. and its specific gravity be about 4,400 or 5,000.

8. Sometimes calamines contain a mixture of calcareous earth and lead. 3 *Lin. von Gmel.* 112. Most of the English calamines contain lead.

9. The first and second Varieties are easily analysed in the moist way, by dissolving them in the dilute vitriolic acid; the filix, if any, will remain undissolved, and the zinc and iron are taken up, and may be separated by adding a piece of zinc previously weighed, and boiling the solution; the iron will be precipitated; the solution, which then contains only zinc, should be precipitated by aerated mineral alkali. 193 gr. of this precipitate are equivalent to 100 of zinc in its metallic form, from which the weight lost by the inserted zinc should be subtracted; the weight of the fixed air and water may be collected by comparing the loss of weight which the ore suffers by calcination and solution in acids.

10. The analysis of the 3d Variety, or calamine, is more complex. Mr. *Bergman* gives us two methods of performing it. The first is to dephlogisticate it in the nitrous acid with

with the assistance of heat and boil away the acid to dryness. Repeat this operation twice or thrice, using each time twice as much of the acid as the ore weighs; and, lastly, dissolve all that is soluble in a fresh portion of nitrous acid: by this means the zinc (and lead if any) with the argill, will be taken up, while the iron, being dephlogisticated, will with the *silex* remain undissolved; if the solution contains lead, the marine acid will precipitate it; after which the vitriolic may be used to precipitate the calcareous earth, if any be contained in the ore, or the lead and other metals may be precipitated by adding a piece of zinc as in N^o 9. The zinc may then be precipitated by the *Prussian* alkali, the weight of which divided by 5 gives that of zinc in its metallic form contained in the ore. The undissolved residuum should be treated with three times its weight of concentrated vitriolic acid, and evaporated to dryness, and all that is soluble extracted with warm water; the iron should be precipitated by the *Prussian* alkali, and the argill by the aerated mineral alkali, which should also be added to the nitrous solution after the zinc is precipitated.

11. The second method is shorter and more ingenious. He distills the vitriolic acid over calamine to dryness; the residuum he lixivates

viates in hot water, what remains undissolved is *silex*; to the solution he adds a caustic volatile alkali, which precipitates the iron and argill, but keeps the zinc in solution, as it is soluble in vitriolic ammoniac; the precipitate he re-dissolves in vitriolic acid, and separates the iron and argill as before.

IV. VARIETY.

Mixed with a notable proportion of Silex.

Zeolytiform.

12. The real contents of this substance were first discovered by Mr. *Pelletier*, a most accurate Parisian chymist. It was long taken for a zeolyte, being of a pearl colour, crystallized, semi-transparent, consisting of laminæ, diverging from different centers, and becoming gelatinous with acids. It was commonly called *zeolyte of Friburgh*, he found 100 gr. of it to contain from 48 to 52 of quartz, 36 of calx of zinc, and 8 or 12 of water.

SPECIES III.

Mineralized by the Vitriolic Acid.

13. This has already been mentioned in the second part.

SPECIES

SPECIES IV.

Mineralized by Sulphur, by means of Iron.

Blende. Pseudo-galena. Black Jack.

14. Of this there are several varieties, generally of a lamellar or scaly texture, and frequently of a quadrangular form, resembling galena, they all lose much of their weight when heated, and burn with a blue flame; their specific gravity is inferior to that of galena. Almost all contain a mixture of lead ore, most of them exhale a sulphureous smell when scraped, or at least when vitriolic or marine acid is dropped on them.

I. VARIETY.

*Bluish Grey, and of a Metallic Appearance,
Glanz Blende.*

15. Its form is generally cubical or rhomboidal, its texture scaly or steel grained; by calcination it loses nearly $\frac{1}{6}$ of its weight; after calcination it is more easily soluble in the mineral acids. 100 Parts of it afforded Mr. Bergman about 52 of zinc, 8 of iron, 4 of copper, 26 of sulphur, 4 of water, and 6 of filix.

16. To analyse this ore in the moist way,
Mr.

Mr. *Bergman* first expelled the water, and part of the sulphur by distillation; the residuum he treated with 3 times its weight of oil of vitriol evaporated to dryness, this lixiviated with warm water, left only 6 parts undissolved; in this solution a polished plate of iron was boiled, which precipitated the copper. He then by means of the phlogisticated alkali, precipitated the zinc and iron. This precipitate being calcined in an open fire, was several times treated with nitrous acid, evaporated to dryness, until the iron was perfectly dephlogisticated; fresh nitrous acid being then added, dissolved the zinc only, which being precipitated by the *Prussian* alkali, the proportion of zinc, in its metallic state, was found as in N^o 10. Neither metal, as contained in the ore, is much dephlogisticated.

II. VARIETY.

Black, Pechblende.

17. Of moderate hardness, does not give fire with steel, frequently crystalized, and then sometimes transparent, or semi transparent; when pulverized, it gives a reddish powder, when heated it decrepitates, and if laid on a burning coal it emits a sulfurous smell, and deposits white and yellow flowers; it is not magnetic even after torrefaction, but loses 25 per cent. of its weight. It is frequently

quently mixed with silver, arsenic, and other metals. 100 Parts of that of Danemora, examined by Mr. *Bergman*, exhibited 45 of zinc, 1 of regulus of arsenic, 9 of iron, 6 of lead, all slightly dephlogisticated, 29 of sulphur, 6 of water, and 4 of silex. 2 *Bergm.* 332.

18. This ore he analysed in the moist way after the following manner, first, by distillation he obtained the water, regulus of arsenic, and part of the sulphur; the residuum he boiled in marine acid, until all that was soluble was taken up. To the solution, after its filtration and some evaporation, he added vitriolic ammoniac, by whose decomposition vitriol of lead was precipitated in some measure, and the remainder of it by further evaporation. This being separated, the remainder was evaporated to dryness, and treated with nitrous acid, and at last calcined to dephlogisticate the iron; the calx of zinc only, was then dissolved in the nitrous acid, and precipitated by the *Prussian* alkali.

III. VARIETY.

Red, or Reddish Brown. Röd Slag of the Swedes.

19. Its texture is generally scaly, sometimes crystalized, and semitransparent, it
Y gives

gives fire with steel, it does not decrepitate nor smoke when heated, yet it loses about 13 per cent. of its weight by torrefaction.

100 Parts of that of Sahlberg, contained by Mr. *Bergman's* analysis, 44 of zinc, 5 of iron, 17 of sulphur, 5 of water, 5 of argill, and 24 of quartz.

20. In analysing this ore, the water and sulphur were obtained as before, nitrous acid was several times distilled to dryness over the residuum, which was at last calcined, and again treated with the nitrous acid, which then left the iron and quartz and a little argill undissolved; the *Prussian* alkali precipitated the zinc from this solution, and after that, the aerated volatil alkali precipitated the argill. The undissolved residuum was treated with oil of vitriol distilled to dryness, which took up the calx of iron, and a small proportion of argill. The *Prussian* alkali precipitated the iron, and the liquor being then evaporated, afforded a little alum and tartar vitriolate.

IV. VARIETY.

Phosphorescent Blende.

21. Its colour is generally greenish, yellowish green, or red, of different degrees of transparency,

transparency, or opaque; when scraped with a knife in the dark, it emits light, even in water, and after undergoing a white heat, when distilled *per se*, a filiceous sublimate rises, which shews it contains the sparry acid, probably united to a metal since it sublimes. It is almost wholly soluble in the marine acid in a boiling heat.

Mr. *Bergman* found 100 parts of that of *Scharfenberg*, to contain 64 of zinc, 5 of iron, 20 of sulphur, 4 of fluor acid, 6 of water, and 1 of filix.

V. VARIETY.

Greyish yellow Blende.

22. This consists of a mixture of blende, galena, and petrol, it contains about 24 per cent. of zinc; it is probably the same as the grey blende of *Monnet Mineral*. p. 400.

VI. VARIETY.

White Blende.

23. Found at *Silverberget Cronst.* §. 230.

VII. VARIETY.

Yellow Blende.

24. Of the colour of wax, and semi-transparent, contains much sulphur, *Mon.* 400.

25. In the dry way zinc is reduced by distilling its ore after torrefaction, with a mixture of its own weight of charcoal, in an earthen retort well luted, and a strong heat; but by this method, scarce half the zinc it contains is obtained.

C H A P. X.

Regulus of Antimony.

1. Its colour is of a silvery white, its texture micaceous; its specific gravity, when perfectly freed from iron, 6,860; it is remarkably brittle; the nitrous acid dephlogisticates it, but holds only a very minute portion of it in solution. The marine has very little effect on it, but it is in a considerable degree, soluble in aqua regia formed of 7 parts marine, and 1 of nitrous acid; or in a mixture of the vitriolic and marine acids, or even of the vitriolic and nitrous. It melts long after it becomes red hot, emits a white smoke, and evaporates, forming white flowers; in close vessels it sublimes without decomposition.

SPECIES I.

Native.

2. This was first discovered in the mine of *Sala* in *Sweden*, by that great metallurgist,
Dr.

Dr. Schwab, in the year 1748; it was composed of shining white irregular planes or *facettes*, resembling *Mispickel*, for which it was long taken, and in effect contained a mixture of arsenic; it has also been lately found in the mines of *Allemond* in *France* by Mr. Mongez the younger, alloyed with about 3 per cent. of arsenic. 23 Roz. 66.

3. Its purity may be examined by boiling it in a large quantity of nitrous acid, which will hold only the arsenic in solution.

SPECIES II.

Mineralized by the aerial Acid.

Native Calx of Antimony.

4. This was also lately discovered by Mr. Mongez; it consists of a group of white crystalized filaments diverging from a common center like zeolyte; urged with a blow pipe on charcoal it will dissipate, which, together with its insolubility in nitrous acid, is sufficient to distinguish it.

SPECIES III.

Mineralized by Sulphur.

Antimony.

5. Its colour is dark, or bluish grey; its texture

texture fibrous, cuneiform, solid, or lamellar; this last is sometimes called *antimonial galena*; its form generally indeterminate, but sometimes crystalized; it is the most fusible of all ores; its specific gravity is from 4 to 4,2, and when melted 4,7 or 5,000; it fulfies the fingers, and is very brittle; when gradually heated in a crucible it loses about 22 per cent. of its weight, and becomes a grey calx; it is perfectly soluble in the marine acid with the assistance of heat; the nitrous only calcines the reguline part, and the vitriolic has but little effect on it; 100 parts of it contain 74 of regulus slightly dephlogisticated, and 26 of sulphur. 3 *Bergm.* 167.

6. It is analysed by solution in aqua regia, consisting of 1 part nitrous, and 4 of marine acid; the sulphur is found on the filter.

7. In the dry way antimony is separated from the stony parts of its ore by distillation *per descensum*; it is afterwards reduced to a regulus by gently roasting it untill it loses 22,5 per cent. of its weight, and then mixing the grey calx thus formed with twice its weight of black flux, and briskly fusing it in a covered crucible.

SPECIES IV.

SPECIES IV..

*Mineralized by Sulphur and Arsenic.**Arsenicated Antimony.*

8. This is the same as the plumose silver ore mentioned among those of silver, Species 11; besides the colours there mentioned, it is found red or green, and then contains but a small proportion of silver; its texture filamentous, very brittle and fusible.

9. It is analysed by solution in *aqua regia*; both the regulus and arsenic remain in the solution; the sulphur is separated by filtration; if the solution be then boiled with twice its weight of strong nitrous acid, the regulus of antimony will be precipitated by dephlogistication, and the arsenic converted into an acid, which will remain in the liquor, and may be procured by evaporation to dryness.

10. If silver or copper be suspected in this ore, it should be treated in as Chap. 3. N^o 25.

C H A P. XI.

Regulus of Arsenic.

1. Of a bright yellowish white colour, but soon loses its lustre, and grows black by exposure

sure to the air ; it is of a loose structure, very brittle, and of a lamellar texture ; its specific gravity is 8,310 ; if laid on a red hot iron it burns with a slight flame, white smoke, and garlick smell, is wholly volatilized, and tinges a plate of copper held over it white ; it is easily soluble in the nitrous acid, more difficultly in the vitriolic, and scarce at all in the marine ; boiling oils also dissolve it ; it detonates with nitre.

SPECIES I.

Native, Scherben Cobalt, Fliegenstein, Cobalt testacé.

2. Of a lead colour, of different degrees of hardness, friable, and of a scaly texture, seldom, if ever, crystalized ; it possesses all the properties of the regulus above described,

3. It may be analysed by solution in aqua regia ; the silver, if any, will remain precipitated ; the iron, of which it commonly contains a small proportion, will remain in the solution ; but if a small quantity of water be added to the solution, the calx of arsenic will be precipitated, and the iron remain.

4. *Mispickel*, which consists of arsenic nearly in a reguline state united with iron, has already
ready

ready been mentioned among the iron ores,
Species 20.

SPECIES II.

Mineralized by the aerial Acid.

*Calci form arsenical Ore, native Calx of Arsenic,
flos arsenici.*

5. It is found either indurated in the form of white opaque, transparent, or semi-transparent crystals, or in a loose powdery state, frequently mixed with native arsenic; it is volatil when heated, though less so than the regulus; it does not detonate with nitre, though an effervescence arises.

Its specific gravity is from 3,706 to 5,000; it is soluble in about 70 or 80 times its weight of water in the temperature of 60, or in 15 or 20 times its weight of boiling water; the solution turns tincture of turnsole *red*, and syrup of violets *green*; it is scarcely soluble in the vitriolic acid, something more in the marine, and most perfectly in the nitrous diluted; when in a powdery form, it is called *flos arsenici*, and has been often taken for a calcareous earth.

6. *White pyrites*, which consists of the calx of arsenic, mixed with sulphurated iron, has
been

been described among the iron ores. Species 19.

SPECIES III.

Mineralized by Sulphur.

7. Of this there are two Varieties, the yellow and the red; both are sublimable in close vessels, detonate with nitre, with fixed alkalis form a hepar, and are soluble in oils.

I. VARIETY.

Yellow, Orpiment.

8. This is rarely found crystalized. Baron Born once found it in a polyhædral form in a blue clay in *Hungary*; it is generally composed of shining, flexible laminæ like mica, more or less solid; its specific gravity is about 3,315; it contains only about $\frac{1}{10}$ of its weight of sulphur; it burns with a blue flame,

II. VARIETY.

Red, Realgar, Raufschgelbe.

9. It is found either in shapeless or stalactitical masses, opaque or semi-transparent, or transparent and regularly crystalized in octohædral pyramids or prisms, and then called *ruby of arsenic*; its specific gravity is 3,225,

Regulus of Arsenic.

331

100 parts of it contain 16 of sulphur; nitrous acid soon destroys its redness.

10. To analyse these ores, they should be digested in marine acid, adding the nitrous by degrees to help the solution; the sulphur will be found on the filter; the arsenic will remain in the solution, and may be precipitated in its metallic form by zinc, adding spirit of wine to the solution. 2 *Bergm.* 442.

SPECIES IV.

Calx of Arsenic diffused through Earths or Stones.

11. *Henckel* mentions a grey or bluish marl in which this calx was found; clay and calcareous stones are also sometimes impregnated with it; it is discovered either by the smell when laid on burning coals, or by lixiviation.

12. In the *dry way* calx of arsenic is separated from the ores which contain it by sublimation in a well luted retort, and a gradual heat, but some always remains, which cannot be expelled but by an open fire and the addition of charcoal.

13. White arsenic, that is, calx of arsenic, is reduced to a regulus, either by quickly melting it with a mixture of 2 parts soft soap,

soap, and two parts of mineral alkali, pouring it when in fusion into a hot iron cone, or by mixing it with oil to the consistence of a syrup, and then with a gradual heat distilling the whole to dryness; towards the end the regulus sublimes, and may be made more perfect by a second distillation with its own weight of oil; by reason of the offensive smell the distillation should be made in the open air.

C H A P. XII.

Bismuth.

1. Bismuth is of a reddish or yellowish white colour, of a lamellar texture moderately hard, and brittle; its specific gravity exceeds that of any of the semi-metals, or even most of the intire metals, yielding only to that of platina, gold, mercury, lead and silver, being from 9,600 to 9,700; its fusibility is nearly as that of lead; it is easily soluble in nitrous acid or aqua regia, but scarcely in the vitriolic, and still less in the marine; its solution is colourless, and is precipitable by the addition of pure water.

2. 113 grains of this precipitate from nitrous acid, well washed and dried, are equivalent to 100 of bismuth in its metallic form.

SPECIES. I.

SPECIES I.

Native.

3. This is the commonest of all native metallic substances, and is generally found either in cubes or octagons, or of a dentritical form, or in that of thin laminæ investing the ores of other metals, particularly those of cobalt, from which it is easily distinguished and separated by its great fusibility; it is said to be sometimes alloyed with silver; if so, they are easily separated by solution in nitrous acid, and the addition of water, which precipitates only the bismuth, and leaves every other metal in the solution.

SPECIES II.

*Mineralized by the aerial Acid.**Native Calx of Bismuth.*

4. When pure it is of a yellowish white colour, and either in a powdery form, or indurated like mortar; but it is frequently of a greenish yellow colour, being mixed with ores of other metals; the red and yellow part is most commonly cobalt ore, though it has often been mistaken for bismuth; it is frequently found in glittering particles interspersed through stones of various kinds; silver, iron, and other metals are also found in it; from
all

all which it is separable by solution in nitrous acid, as before explained.

Mineralized by the vitriolic Acid.

Wismuth Bluth.

5. This is said to be of a yellowish, reddish, or variegated colour, and to be found mixed with the calx of bismuth, incrusting other ores. Veltheim Grundriss.

Mineralized by Sulphur.

6. It is chiefly found in *Sweden*, is of a bluish grey colour, lamellar texture, and tessellar form like galena, but much heavier; it sometimes presents parallel striæ like antimony, and its colour is variegated; it is said to contain besides bismuth also cobalt and arsenic. 3 *Lin. von Gmelin*, 133. This ore is very fusible, and the sulphur mostly separates on scorification; it is soluble in nitrous acid, and is analysed like the foregoing ores.

Mineralized by Sulphur with Iron.

7. This is said to be of a lamellar cuneiform texture, and to be found in *Norway*.

8. In the dry way bismuth is extracted from its stony ores by mixing 2 parts of the pulverized

pulverized ore with 1 of pounded glass, and 1 of calcined borax, melting the whole in a crucible lined with charcoal.

C H A P. XIII.

Cobalt.

1. Cobalt, or regulus of cobalt, as it is called by some, is of a bluish grey colour, very hard, brittle, and steel grained; its specific gravity is about 7,700; its fusibility is nearly as that of copper; it is difficultly calcined, and its calx is of a blue, so deep as to appear almost black; and this calx melted with borax, or potash and white siliceous sand, gives a blue glass: this calx is not volatil; the regulus is easily soluble in spirit of nitre or aqua regia, and the colour of the solution is red, but difficultly in the vitriolic and scarce at all in the marine acid; the calx is more easily dissolved by these acids; it yields even to the acetous.

SPECIES I.

Native.

2. This has not as yet been found; that which passes for such is mineralized by arsenic.

SPECIES

SPECIES II.

Mineralized by the aerial acid.

*Black Ochre of Cobalt, Vitreous Ore of Cobalt,
Kobalt mulm, Schlaken-Kobalt.*

3. This appears either in a loose, powdery form, sometimes as fine as lamp black, either grey or blackish, and called cobalt ochre, or in black indurated scoriform masses, called *Schlaken Kobalt*, or vitreous cobaltic ore: they are both commonly free from sulphur and arsenic, and when there are any, they are only mechanically mixed with this ore; some small proportion of copper and iron is also sometimes found in it; it is frequently imbedded in stones or sands of a black colour; talc, chalk and gypsum impregnated with it have been called by the same name, and by some *Spiegel Cobalt*; it is also contained in some green and blue earths as already mentioned, p. 78, and 79.

4. To analyse this ore let it be dissolved in the nitrous acid; a plate of copper dipped in the solution will discover and precipitate the silver, if any, and a plate of iron will discover and precipitate copper, if the solution contains any; but it should speedily be withdrawn lest the cobalt also should be precipitated;

tated; then the whole should be precipitated by a fixed alkali, and dephlogisticated by abstraction of the nitrous acid and calcination; if the calx be then digested in distilled vinegar, the cobaltic part alone will be taken up, and may be precipitated by mild mineral alkali. 160 gr. of this precipitate denote 100 of cobalt in its metallic state.

SPECIES III.

Mineralized by the Vitriolic or Arsenical Acids.

Red Cobalt Ochre, Kobalt bluth, Fleurs de Cobalt.

5. This also is found either *loose* and pure, or mixed with chalk or gypsum, or *indurated* and crystalized in tetrahædral crystals, or in a stalactitical form; it melts easily, and then becomes blue; it frequently invests other cobaltic ores, and is found sometimes in stones, or sand. Mr. *Bergman* has shewn that the arsenical acid, and not the calx of arsenic, enters into this combination, for cobalt is never red, but when united to an acid.

6. To analyse this ore, Mr. *Bergman* advises to dissolve it in water, acidulated with some acid (suppose the nitrous) and then to precipitate the cobaltic part with mild mineral alkali; the liquor will contain cubic
Z nitre

nitre and Glauber's salt, if the vitriolic acid be the mineralizer, or arsenicated soda, if the arsenical acid exists in the compound,

SPECIES IV.

Mineralized by Arsenic, with scarce any Iron.

Grey Cobalt Ore. Stahl derben Kobalt, Glantz Cobalt.

7. Solid, heavy, compact, sometimes of a dull, and sometimes of a bright appearance, frequently crystalized in a tessellar, sometimes in a dendritical form, and generally so hard as to give fire with steel.

8. It is analysed by solution in aqua regia, or nitrous acid and evaporation to dryness; the residuum treated with the acetous acid will yield to it the cobaltic part; the arsenic should at first be precipitated by the addition of water.

9. Or else this ore may first be roasted to expell the arsenic, and then treated with nitrous acid, the cobalt will be dissolved with very little of the iron, then by boiling the solution most of the iron will be precipitated, and by adding a fixed alkali, the remainder of the iron will first be precipitated yellowish, and afterwards the cobalt reddish. *Mem. Berl.*

1779. p. 16. So also the *Prussian* alkali will first precipitate the iron blue, and afterwards the cobalt reddish, (*ibid.*) or rather grey.

SPECIES V.

Mineralized by Sulphur and Arsenic with Iron.

White arsenicated Cobalt Ore, Kobalt Glantz.

10. This bears a great resemblance to the last, but is softer, for it never strikes fire with steel, and sometimes it is so soft that it may be scraped with a knife; it mostly appears under some polygon form; the most shining sorts of this, and of the former Species, have been called *Cobalt Glantz*.

It is analyzable like the former Species; the sulphur may be caught on the filter.

SPECIES VI.

Mineralized by a small Proportion of Sulphur, with a notable Proportion of Iron without any Arsenic.

White unarsenicated Cobalt Ore.

11. It is sometimes found in large masses, and sometimes in grains crystalized, of a dull white colour, and frequently bears the appearance

pearance of mispickel; it becomes black, and not red by calcination, which distinguishes it from pyrites; it contains so little sulphur, that none can be extracted from it; when dissolved in aqua regia, its solution is yellow while cold, but greenish when boiling, which vicissitude of colour is peculiar to marine cobalt; it contains much more iron than it does cobalt.

12. In the dry way cobaltic ores, after freeing them from their matrix by washing, and from sulphur and arsenic by roasting, are reduced by melting them with three parts black flux in a lined and covered crucible, in a smith's forge; the best ores contain from 60 to 80 per cent. of regulus, the worst under 25 per cent. Smalt is reducible in the same manner,

13. To assay the tinging power of cobaltic ores, the roasted ore is melted with three times its weight of pot-ash, and five times its weight of pounded glass or flint, putting in the pot ash first, then the glass or flint, and over all the ore. *Scheff.* 322.

14. If any bismuth be contained in the cobalt ore, it will not mix with the regulus of cobalt, unless nickel also be contained in it, but will simply adhere to it, and may be separated

parated by the hammer, or by melting it, as it melts much easier than cobalt; when cobalt is by means of nickel united to bismuth, the compound is called *Speiss*; so also is a compound of cobalt, nickel, bismuth, sulphur and arsenic.

15. In general, cobaltic ores are known by their property of affording sympathetic ink when digested in aqua regia, after the bismuth is precipitated by the addition of water.

C H A P. XIV.

Nickel.

1. Nickel is a reddish white semi-metal of great hardness, so that it can scarce be filed, and of an equable texture; its specific gravity varies according to its purity from 7,421 to 9,000, the purest being the heaviest; when very pure it is in some degree malleable, and always magnetic, and hence it is deemed to retain iron. The fusibility of the common regulus is nearly as that of copper: it calcines more difficultly than cobalt; its calx is green, and rises in a tuberosc fungous form; it is difficultly soluble in the vitriolic or marine acid, but easily in the nitrous; all these solutions are green, and volatil alkali turns them

blue, but iron discovers no copper in them, as it does in every combination of copper, sulphur, iron, arsenic and cobalt. Hence nickel must be deemed a distinct semi-metal: besides, Mr. *Bergman* has shewn that sulphur, arsenic and cobalt may be perfectly separated from it, though perhaps iron cannot; but it seems to me very probable that nickel itself may be magnetic: the purest regulus is much more difficultly calcined or melted.

SPECIES I.

Native.

2. This is mentioned by Mr. *Rinman* to have been lately found in a mine of cobalt in *Hesse*; it is very heavy, and of a liver colour, that is, dark red; when pulverized and roasted under a muffle, it forms green excrescences, and smokes, but its smoke has no particular smell, and no sublimate, whether sulphureous or arsenical, can be caught; it is soluble in acids, and the solution is green; but a polished iron plate discovers no copper.

SPECIES II.

*Mineralized by the aerial Acid.**Native Calx of Nickel.*

3. It is found in the form of a green calx,
mixed

mixed with calx of iron, scattered over the ore of kupfernickel; also in some green clays. *Cronst.* §. 255.

SPECIES III.

Mineralized by the Vitriolic Acid.

Vitriol of Nickel.

4. Already mentioned in the 2d Part, p. 195.

SPECIES IV.

Mineralized by Sulphur and Arsenic, with Cobalt and Iron.

Kupfernickel.

5. This is of a reddish yellow bright colour; its texture either uniform, granular or scaly, bright in its fracture, very heavy, and generally covered with a greenish efflorescence; by calcination it loses much of its sulphur, and becomes green, forming fungous ramifications.

6. Its analysis in the moist way is as yet very imperfect; by solution in the nitrous acid it is freed from its sulphur, and by adding water to the solution, bismuth, if any, may be precipitated, as may silver, if con-

tained in it by the marine acid, and copper when any by iron. To separate cobalt from nickel when the cobalt is in considerable quantity, Mr. *Gerhard* advises to drop a saturate solution of the roasted ore in nitrous acid, into liquid volatil alkali : the cobaltic part is instantly re-dissolved, and assumes a garnet colour ; when filtered a grey powder remains on the filter, which is the nickel : the cobalt may be precipitated from the volatil alkali by any acid. *Mem. Berlin*, 1779, p. 17 and 18. cobalt may also, in some measure, be separated from nickel, by melting it with three times its weight of liver of sulphur ; the cobalt will be taken up, and may be separated by lixiviation. 2 *Bergm.* 244.

7. In the dry way a regulus is obtained from the ores of nickel by long continued torrefaction, which expels much of the sulphur and arsenic, and then melting the green calx thus obtained, with twice or thrice its weight of black flux in an open crucible covered with common salt by the strongest fire of a smith's forge, a regulus is found, which amounts to from 30 to 50 per cent. of the weight of the green powder : this regulus still contains sulphur, arsenic, cobalt and iron ; its further depuration is very laborious, and may be seen in the second volume of Mr. *Bergman's* works.

8. It

8. It is highly probable that nickel exists in some species of roof slates, and in hornstones, whose solution in spirit of nitre is of a green colour.

C H A P. XV.

Regulus of Manganese.

1. This semi-metal was for the first time clearly described, and its properties admirably investigated and explained by Mr. *Scheele* in the *Memoirs of Stockholm*, for the year 1774. It was afterwards exhibited in its metallic form by Mr. *Gahn*, and its properties in that state, described by Mr. *Bergman* in the second volume of his works; since that publication it has frequently been produced in France by Messrs. *Morveau* and *Lapeirouse*, and lately here by Mr. *Woulfe*.

2. This regulus is of a dusky white colour, an irregular and uneven surface, arising from its imperfect fusion; in its fracture it is bright and shining, but soon tarnishes by exposure to the air; it is harder than iron, less fusible, and very brittle; its specific gravity is 6,850. When pulverized it is always magnetic, though larger pieces be not so; if it be exposed to the air, particularly in moist weather, it soon crumbles into a blackish brown powder,

der, which is something heavier than the regulus. It is soluble in acids, but most readily in the nitrous, and its solutions are mostly colourless, but that in the nitrous is generally brownish from a slight taint of iron, but there is always a spongy residuum of the nature of plumbago, left undissolved. These solutions give a white precipitate with aerated alkalis, which precipitate when heated grows black.

3. The regulus is obtained by mixing the calx or ore of Manganese with pitch, making it into a ball, and putting it into a crucible lined with powdered charcoal $\frac{1}{10}$ of an inch thick on the sides, and $\frac{1}{4}$ of an inch at bottom, then filling the empty space with powdered charcoal, covering the crucible with another inverted and luted on, and exposing it to the strongest heat of a forge for an hour or more.

SPECIES I.

Native.

4. This has not as yet been found, nor can it be expected, (unless perhaps alloyed in native iron) as manganese loses the proportion of phlogiston necessary to its metallic form, more readily than any other metallic substance.

SPECIES

SPECIES II.

*Mineralized by the Aerial Acid.**Native Calces of Manganese.*

5. The aerial acid is the only mineralizer of manganese in a dry state, yet known; and according to the different degrees of phlogistification of the manganese, it forms with it calces of different colours and different properties, to understand which it is necessary to remark, that when manganese is as much phlogistified as it can be, without being in a reguline state, it forms a *white* calx, which contains a large portion of fixed air (about 40 per cent.) which enables it to retain phlogiston, as the compound of acid and calx, attracts phlogiston more strongly than either does when single; in proportion to its dephlogistification, and by union with other substances, its colour is either *blue, green, yellow, red, brown* or *black*; *blue*, is that which it acquires from the proportion of phlogiston, which it is enabled to retain by reason of its union with fixed alkalis; *green* arises from a mixture of the blue with the yellow calx of iron; *yellow* always arises from the prevalence of the calx of iron; *red*, from a slight phlogistification of the calx of manganese; *black*, from its thorough dephlogistification.

cation. Yet if the black calx be long roasted, it becomes *green*, which I think arises from the expulsion of fixed air, which leaves its phlogiston with the manganese, and thus produces a *blue*, which mixed with the yellow calx of iron, gives a *green*; *brown* arises from a mixture of the red and black calces of manganese. These observations I have extracted from Mr. *Scheele's* incomparable dissertation.

6. All these calces, of whatever colour they may be, communicate a *garnet* colour to glass of borax, when treated with a blow pipe, for being melted into a round globule, the surrounding atmosphere dephlogisticates them sufficiently to make them assume this colour.

7. Hence we may distinguish 3 principal varieties of the native calx of manganese, the white, the red, and the black.

I. VARIETY.

White Ore of Manganese.

8. This contains but a very small proportion of iron; it has been found by Mr. *Rinman* both in small white crystals, and in round masses in the cavities of quartz and adhering to glanzblend, rather less hard than limestone,

stone, of a sparry texture, and scarcely magnetic even after roasting, soluble with effervescence in nitrous acid, and affording a colourless solution, which solution, with mild alkalis, gave a white precipitate, and the precipitate, when heated, presently grew black; a sure criterion of manganese. *Mem. Stock.* 1765.

9. Mr. *Lapeirouse* found this white ore in the form of a spongy efflorescence, vegetating on the surface of some iron ores, particularly hæmatites.

10. It has been seen also by Mr. *Rinman* in the form of a calcareous spar, of the colour of rosin, and somewhat shining, in some places covered over with a footy powder, and in thin pieces semi-transparent at the edges, and not hard enough to strike fire with steel; nitrous acid dissolves it almost intirely, with mild alkalis the solution gives a white precipitate, which blackens when heated. It consists of *manganese imbedded in zeolyte*, it melts *per se* with the blow pipe into a whitish grey porous slag, and with the addition of calcined borax gives a garnet coloured glass.

11. Many of white sparry iron ores may also be classed among the ores of manganese,

nese, as they contain more of it than of iron.

II. VARIETY.

Red Ore of Manganese.

12. It contains less fixed air, and is accompanied with more iron than the former variety, and also with calcareous or ponderous earth and silica. It is found either loose and semi-indurated in a matrix of calcareous spar, or talky shistus, or on hæmetites and other iron ores, or in heavy hard masses of a lamellar, radiated, or equable texture, or crystalized in pyramids, rhomboids, or short bright brittle needles. 15. Roz. 69.

III. VARIETY.

Black and Brown Ore of Manganese.

13. I place these together, as they differ but little; they are found either crystalized in the same form as the red ore, or in solid masses, some of which have a metallic appearance, others are dull, earthy, and mixed or embodied with quartz, or in a loose earthy form; their specific gravity is about 4,000 both, particularly the brown and the red are soluble in some measure by digestion in oil of vitriol, and the solution is at first reddish, but afterwards

afterwards becomes colourless, unless they contain a large proportion of iron. But the dephlogisticated nitrous acid does not act on them except sugar be added, and then this acid, as well as the concentrated vitriolic, operates a colourless solution, which with mild alkalis, gives a white precipitate of the same nature as the first variety; they contain more iron and less fixed air than the former varieties.

14. *Perigord Stone* belongs to this variety, it is of a dark grey colour like basalt or trapp, may be scraped with a knife, yet is difficultly broken; when calcined it becomes of a reddish brown colour and harder, but not magnetic. Its specific gravity is considerable, it does not melt *per se*, but with borax it affords an amethystine glass; nitrous acid scarcely acts on it without the addition of sugar, this stone seems also to contain argill, and some portion of iron.

15. One of the most remarkable ores of manganese is that called *black wad*; it is of a dark brown colour, partly in powder and partly indurated, and brittle. If half a pound of this be dried before a fire, and afterwards suffered to cool for about an hour, and then two ounces of lintseed oil be gradually poured on it, mixing them loosely like barm with flour,

flour, little clots will be formed, and in something more than half an hour the whole will gradually grow hot, and at last burst into a flame, as I have seen several times at the house of Sir *Joseph Banks*. The temperature of the room where the experiment was made was about 50 : the heat this ore was exposed to while drying might be about 130.

16. According to Mr. *Wedgewood's* analysis 100 parts of black wad contain 43 of manganese, 43 of iron, 4,5 of lead, and 5 of mica.

17. To analyse the abovementioned ores, they should be first roasted to dephlogisticate, the calx of manganese, and iron if any, then treated with dephlogisticated nitrous acid to dissolve the earths ; the residuum should then be treated with nitrous acid and sugar, by which means a colourless solution of manganese will be obtained, which being precipitated by aerated mineral alkali, will give a precipitate 100 gr. of which are equivalent to 100 of regulus of manganese.

18. Many species of iron ore contain manganese. To discover it, let the iron be dissolved in some acid, and precipitated by the *Prussian* alkali ; let the solution be poured off, and the precipitate digested in pure water ;

water; the *Prussian* manganese will be dissolved, and the *Prussian* iron remain undissolved. See also Chap. 5. N^o 41 and 53.

Manganese in Vegetables.

19. “ Manganese seems to be contained
“ in the ashes of most vegetables, and to it
“ the blue or greenish colour of calcined vegetable alkali is owing. These colours
“ are generally attributed to the phlogiston
“ of the alkali; but if so, they should not
“ be found in fixed nitre, as the nitrous acid
“ should carry off during its decomposition
“ all the phlogiston; yet this alkali is always
“ greenish, so that the colour seems to arise
“ from the ashes of the charcoal with which
“ the nitre was decomposed. If 3 parts of
“ the alkali of tartar, 1 of sifted ashes, and
“ $\frac{1}{8}$ of nitre be melted together, they form
“ a dark green mass, which being dissolved
“ in water affords a beautiful green solution,
“ and this being filtered, on the addition of a
“ few drops of oil of vitriol, becomes red,
“ and after a few days a brown powder is
“ deposited, which has the properties of
“ manganese.” *Scheele* 56 *Mem. Stock.*
1774, p. 189. The ashes of *serpyllum* contain very little of it, those of trees contain most. *Ibid.* 180.

CHAP. XVI.

Siderite.

1. The first distinct mention I find made of this substance is in the *Mineralogy* of Mr. Monnet, p. 384, printed in 1779; but the merit of discovering its nature is undoubtedly due to Mr. Meyer of Stetin, who, not contenting himself with vague generalities, developed its principal properties by a series of ingenious and well connected experiments published among the Memoirs of the philosophical society of Berlin for the year 1781 and 1782; some few of which he also mentioned in the Memoirs of the preceding year. Mr. Bergman, ignorant of what Mr. Meyer had done, arrived at the same conclusions nearly at the same time, as may be seen in the 3d volume of his works, and discovered some additional properties of this new semi-metallic substance. From these sources I have extracted the following account of it.

2. Siderite is principally found in iron, of the first fusion or cast iron, and in the ores of coldshort iron. The manner of its extraction has been already mentioned, Chap. 5. N^o 46. A pound of cast iron sometimes affords
about

about 12 drachms of this calx, whose natural colour is white, but it is generally tinged brown or yellow from a mixture of the calx of iron. Mr. *Bergman* purifies it by repeatedly abstracting the nitrous acid over it, which dephlogisticates the iron, and leaves the calx of siderite soluble in the mineral acids, but not in the acetous.

3. The solutions of it in the vitriolic and marine acids crystalize, though very difficultly; it rather tends to form a jelly, particularly if there be an excess of acid; the solution in the nitrous is reddish, and in the marine yellowish; all are slowly precipitable by water.

4. This calx is also in some measure soluble in water, but 1 part of it requires 1500 of boiling water for its solution.

5. Alkalis, both fixed and volatil, have some action on it, and acquire a brown tinge from it,

6. In the dry way it melts *per se* on charcoal, and is not volatil; it gives glass a green colour, except it meets phlogiston, and then the colour is brown,

7. It is reduced to a regulus by melting it
A a 2 with

with half its weight of borax in a crucible lined to the thickness of $\frac{1}{10}$ of an inch with a mixture of charcoal and a little clay, and exposing it to the fire of a smith's forge for three quarters of an hour.

8. The regulus is of a steel grey colour, not so hard as cobalt, exceeding brittle, not magnetic in small pieces, though slightly so when powdered. Its texture is granular; its specific gravity about 6,710.

9. Its fusibility is nearly as that of copper, and it seems to contain something more phlogiston than iron does; it is not volatile when heated.

10. It is very difficultly soluble in any acid, and requires the assistance of heat; after ebullition for some days the nitrous acid out of 5 grains dissolved only 4, aqua regia 4,2, dilute vitriolic acid 3,5, and the marine 3. Infusion of galls turns these solutions black; the *Prussian* alkali gives a dark blue precipitate, and common alkalis a white precipitate.

11. It precipitates gold, silver and copper very slowly from their solutions, and in their metallic form; but lead from nitrous acid in the form of a calx; it does not precipitate mercury from the nitrous acid.

12. It

12. It is itself precipitated from the nitrous acid in the form of a brown calx by zinc and iron. Copper seems to precipitate only a little dephlogisticated iron from it, to which a little of the white calx is united; lead also produces the same effect.

13. It does not detonate with nitre, though it alkalizes it, and is dephlogisticated by it.

14. It does not unite with sulphur.

15. It sublimes with sal ammoniac, and takes a yellow colour.

16. It does not amalgamate with mercury, but when in fusion it unites with iron, copper, or cobalt, but not with any other metal, except perhaps nickel, which has not been tried; it converts bar iron into the state of crude or cast iron, and when in a smaller proportion renders it *coldshort*.

C H A P. XXII.

Molybdena. Molybdena membranacea Cronst.

154. *Wasserbley of the Germans.*

1. It resembles plumbago, but its laminæ are larger, brighter, and when thin slightly flexible; it is of a lead colour, and does not

A a 3

strike

strike fire with steel; its specific gravity is 4,569.

2. In an open fire it is almost intirely volatil and infusible. Microcosmic salt or borax scarcely affect it, but it is acted upon with much effervescence by mineral alkali, and with it forms a reddish mass, which smells of sulphur.

3. It is affected by no acid, but the nitrous and arsenical, both require the assistance of heat; the latter is converted into orpiment.

4. Mr. *Scheele* has found it to consist of an acid of a peculiar nature united to sulphur; a small proportion of iron is commonly found in it; but this seems merely fortuitous; 100 parts of it contain about 45 of acid, and 55 of sulphur.

5. It is decomposed either by detonation with nitre, or by solution in nitrous acid: this latter method is the readiest: for this purpose it is to be 5 times distilled, each time with 4 times its weight of spirit of nitre; a white calx at last remains, which is the molybdenous acid.

6. This acid is soluble in 570 times its weight

weight of water in the temperature of 60; the solution reddens that of litmus, precipitates sulphur from the solution of liver of sulphur, &c. the specific gravity of the dry acid is 3,460. 3 *Bergm.* 127.

7. This acid is precipitable from its solution in water by the *Prussian* alkali, and also by tincture of galls the precipitate is reddish brown.

8. If this acid be distilled with three times its weight of sulphur, it re-produces molybdena.

9. The solution of this acid in water unites to fixed alkalis, and forms crystallizable salts; so it does with calcareous earth, magnesia, and argill: these last combinations are difficultly soluble; it acts also on the base metals, and with them assumes a bluish colour.

10. This solution precipitates silver, mercury, or lead from the nitrous acid, and lead from the marine, but not mercury.

It also precipitates barytes from the nitrous and marine acids, but no other earth. Molybdenous baroselenite is soluble in cold water.

11. This acid is itself soluble in the vitriolic acid with the assistance of heat, and the solution is blue when cold, though colourless while hot ; it is also soluble in the marine acid, but not in the nitrous.

12. Molybdenous tartar and ammoniac precipitate all metals from their solutions by a double affinity. Gold, sublimate corrosive, zinc and manganese, are precipitated *white* ; iron or tin from the marine acid *brown* ; cobalt *red* ; copper *blue*.

13. Alum and calcareous earth white. *Scheele Mem. Stock, 1778.*

14. This acid has been lately reduced by Mr. *Helm*, but the properties of the regulus thus obtained are not yet published.

C H A P. XVIII.

Of the Tungstenic Acid.

Though this acid, and the manner of obtaining it have been already mentioned, p. 38, yet as it is of a metallic nature, a few of its distinguishing properties may properly be inserted here.

1. Its solution in water reddens that of litmus ;

litmus; with alkalis it forms crystalizable salts; with barytes calcareous earth, and magnesia insoluble compounds.

2. This solution is precipitated white by the *Prussian* alkali, and the precipitate is soluble in water.

3. It precipitates the solutions of vitriols of iron, zinc, copper, and the nitrous solutions of silver, mercury and lead, and that of lead in marine acid; all these precipitates are white: the solution of tin in marine acid is precipitated blue, but the solutions of gold and sublimate corrosive are not altered by it.

4. The solutions of chalk or alum are not altered by it, but that of barytes in the acetous acid is precipitated, and the precipitate is insoluble.

C H A P. XIX.

Saturnite.

The substance to which I ventured to give this name, is said by Mr. *Monnet*, to be found in the lead mines of *Poullaoven* in *Brittany*, and is separated from the lead ore during its torrefaction. According to him it resembles lead in its colour and specific gravity,

gravity, is soluble in the same acids, and with the same phenomena ; but it is much more fusible, very brittle, easily scorified and volatilized, and refuses to mix with lead when in fusion. It were to be wished it was better examined.

C H A P. XX.

Reflexions on the nature of Cobalt, Nickel, and Manganese.

1. The principal reason why any simple substances are reckoned specifically different from each other, is their manifesting properties permanently different in the same circumstances, and every substance must be deemed simple, until it can be resolved into different principles, or formed out of them. Every other indication is at best a surmise grounded on mere possibility, but destitute of probability, and therefore inadmissible in any exact scientific system ; upon this foundation most chymists and mineralogists have admitted the abovementioned substances to a distinct rank among semi-metals. Yet as some others deservedly of great note, namely, Mr. Pabst, Mr. Monnet, and Romé de Lisle, have asserted, that all, or some or other of these semi-metals, are either modifications of iron, or compounds of some sort ; I presume it will not be amiss before I conclude this treatise, to
state

state the reasons they have alledged, and justify the opinion I have followed.

Of Cobalt.

2. With regard to cobalt, some have thought it to be nothing else but a compound of iron and arsenic, asserting that such a compound would communicate a blue colour to glass, but this pretension has been fully refuted by the experiments of Mr. *Brandt. Mem. Sued.* p. 46 and 47. and those of Mr. *Monnet. Diff. Des. Mett.* p. 279.

3. Others have thought that the tinging quality is produced in cobalt, merely by its union with arsenic, because it sometimes happens, that cobalt will not tinge, unless arsenic be added to it. But the true reason of this phenomenon is, that cobalt will not tinge unless it is dephlogisticated, nor even then unless it melts, and it sometimes happens that cobalt is too much dephlogisticated, and then it will not melt in the usual heat, without the addition of arsenic, which serves as a flux to it; for that arsenic is not otherwise essential to its tinging property is evident from this, that some cobalt ores, which tinge admirably well, are yet absolutely free from arsenic, such as the vitreous ore, *Sp. 2d.*

It

4. It is true, that in some circumstances glass may be tinged blue by iron, as Mr. *Gmelin* has learnedly shewn in the 5th part of Mr. *Crell's Chymical Journal*; but this iron is not transformed into cobalt; for if that glass be digested in aqua regia, the solution will not form a sympathetic ink; but, on the contrary, will manifest every property of iron; whereas glass tinged blue by cobalt will, when digested with aqua regia, afford sympathetic ink, and manifest the other distinctive characters of cobalt.

Nickel.

5. Mr. *Monnet* thinks that cobalt and nickel are one and the same metal, which when united to iron, exhibits the properties of, and is called *cobalt*, but when free from iron, is called *nickel*; so that nickel is the simple substance, and cobalt the compound. The solutions of cobalt he adds are red, merely on account of the iron, otherwise they would be green like those of nickel; the blue tinging matter he says is inherent in cobalt, but it cannot be developed without the addition of iron and arsenic. This opinion carries its own refutation with it, for common nickel always contains at least as much iron as cobalt does, and yet constantly gives glass a reddish yellow colour, and if ever the addition of
arsenic

arsenic makes it give a blue tinge to glass, it is because it contains a portion of cobalt, which is not easily dephlogisticated, but remains in a reguline state, and while it remains in this state, it can give no colour to glass, but the addition of arsenic dephlogisticates this portion of cobalt, and thus enables it to unite to, and tinge glass, and this is so true, that the addition of nitre, which dephlogisticates still more powerfully than arsenic, produces the same effect, as Mr. *Bergman* has shewn in his elaborate dissertation on Nickel, 2 Nov. Act. Ups. p. 243. so that arsenic is no way necessary; and moreover it is absolutely false, that the addition of iron and arsenic will ever give nickel the properties of cobalt, as Mr. *Monnet* himself must well know. However, the reasons he alledges to prove the identity of these semi-metals are,

6. 1^o That cobalt and nickel are soluble in the same acids, and acted on by these acids in the same manner, all the difference being that the solutions of cobalt are red, and those of nickel green; a difference assuredly very great, and which no addition of iron and arsenic to nickel will alter, as it should according to his system; for let him combine iron and arsenic with nickel as he pleases, he will never make a substance whose solution in acids will be red, as that of cobalt is. But further, if
by

by *acids* he means the mineral acids and the acetous, then he may as well say that bismuth is the same substance as cobalt and nickel, for it is acted upon by these acids in nearly the same manner, but if he means the long tribe of other acids, the assertion is not true, since the tartarous acid for instance does not act on nickel, whereas it does on cobalt.

7. 2^{ly}. Because though the ores of Nickel become *green* by calcination, and those of cobalt, *blue*, yet if the calcination of the nickel be continued, its calx will become *brown*; but I do not see how this change to a reddish brown, approximates nickel to cobalt, any more than the green colour does, for it is equally different from the blue or chocolate colour of cobalt, and it appears from Mr. *Bergman's* experiments, that the green colour arises from a mixture of arsenic, for when nickel is thoroughly free from it, its calces are brown.

8. 3^{dly}. Because nickel long exposed to the air, contains a green rust, as does cobalt. But this appearance would as well indicate copper:

9. 4^{thly}. Because both nickel and cobalt unite with the same metals. He probably forgot

forgot that cobalt and bismuth will not unite, nor will cobalt and silver, or cobalt and lead, whereas nickel will unite to any of them when well purified from cobalt, and with bismuth, even without such purification.

10. 5^{thly}. Because according to *Cronsted* himself, nickel will give a blue colour to borax. But Mr. *Bergman* has shewn, that when it is well purified from cobalt, it will give a hyacinthine, and not a blue tinge to borax. Mr. *Monnet* adds, that cobalt, melted with quartz and alkali, gives a *greenish* brown glass in some circumstances, and quotes *Brandt*, but *Brandt* says the colour was *reddish* brown, and in effect this colour should be expected from the species of cobaltic ore he examined, which was loaded with iron, and from the manner in which the experiment was conducted, the cobalt being too much dephlogisticated,

11. Lastly, he observes that the cobalt is always magnetic; but it is to be observed, that this magnetism constantly decreases in proportion as it is freed from iron, and yet the cobalt remains in full possession of all its properties, therefore its properties do not depend on the presence of iron, and if it were perfectly free from iron (a state of purity to which Mr. *Monch* says he has reduced it. 3 *Crell*. p. 164) it would
not

not be in the least magnetic; besides this argument would subvert Mr. *Monnet's* own opinion, for nickel is also always magnetic.

12. Mr. *Romé de Lisle* thinks that nickel consists of iron, cobalt and copper intimately united :* although Mr. *Bergman* has demonstrated that this opinion is destitute of any proof, either synthetic or analytic; for, in the first place, he mixed these substances in various proportions, but could produce nothing that resembled nickel; and, in the 2d place, he shewed that copper is very seldom mixed with it, and when it is, may easily be separated, and cobalt also may be separated though more difficultly. But Mr. *Romé* looks on the blue colour which volatil alkalis produce in the solutions of nickel, as an evident sign of its containing copper. To make this proof of any weight, we must assume this principle; *that two different metals cannot give the same colour to the same menstruum*, which is evidently false, for gold and platina give the same colour to aqua regia, to say nothing of the various metals, whose solutions in nitrous acid are colourless. The only consequence strictly deducible from the colour of a *menstruum* is purely negative; namely, *that it does not*

* *Chrysilographie*, p. 91.

singly contain any substance, which is known to communicate a different colour to that menstruum in the same circumstances ; for there is scarce any one property of any substance that may not be communicable to some other substance, as it is only the aggregate of all their properties that fully distinguishes substances from each other.

13. He further adds, that nickel cannot be looked upon as a distinct semi-metal, because it cannot be thoroughly purified from iron. What stress should be laid on this argument, we shall presently consider in treating of manganese ; but in the mean time we may observe that it is far from being clear that nickel can never be purified from iron ; for the only ground of this suspicion is, that the purest nickel is magnetic ; but this must be deemed insufficient, unless it be taken for granted that magnetism is a property inherent in iron only, and incommunicable to all other possible metallic substances, as we know it is to those that are already known ; a position which seems to me fully contradicted in the case of nickel ; for when it is purified as much as possible from iron, it becomes *more* instead of *less* magnetic, and even acquires what iron does not, the properties of a magnet. What hinders us then from allowing magnetism, like the property of giving

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ing a blue colour to alkalis, to be common to those different metallic substances in which we find it?

Manganese.

According to Mr. *Romé* this semi-metal is a mixture of iron, zinc and cobalt: that it contains iron is not denied; but it is asserted, that besides iron it contains a peculiar semi-metal, whose properties are independent of the presence of iron, since they are absolutely different from those of iron, and every alloy of iron with any other known metallic substance, and are so much the more apparent, as the portion of iron it contains is diminished. Nevertheless, Mr. *Romé* objects that the regulus of manganese can never be totally freed from iron, and that all the experiments hitherto made upon it being made on a mixed semi-metal, the properties discovered by these experiments should be deemed those of a mixed, and not those of a simple substance. But the fallacy of this reasoning will readily appear, if it be considered that, though until lately, platina could not be obtained perfectly free from iron; yet the most judicious chymists in Europe, *Lewis*, *Margraaf*, *Scheffer*, *Macquer* and *Baumé*, were of opinion that it was a peculiar distinct metallic substance; and at this day regulus of antimony and tin are never absolutely free from

from iron, yet no one dreams of attributing their peculiar properties to an alloy of iron, and any other metal; and indeed if this manner of reasoning were of any weight, no properties could be attributed to any simple substance; for what substance can be procured absolutely pure? When was water rigorously pure ever found or procured, or gold of 24 carats? Unless therefore we can produce by art a compound similar to that which we presume to be a mixture, or shew some good reason why such a compound cannot be artificially produced, or unless we can decompose such substance, and thereby destroy its peculiar properties, or at least alter them by the subtraction of any one of its supposed constituent parts, we must look upon the supposition that such substance is essentially a *compound*, as groundless relatively to the present state of our knowledge, on which alone, and not on mere possibilities, we can rationally found any assertion. The word *modification* has been strangely abused on this occasion. Cobalt, nickel and manganese, have been said to be only modifications of iron; but as long as it is not known wherein that modification consists, this word presents no idea whatsoever; and any other insignificant word may as well be used. If it be said that it denotes *iron with the addition of some unknown substance*, then it would follow at

least, that by diminishing the proportion of iron, the specific properties of the compound would be altered, which is not true with respect to these semi-metals, for the freer they are from iron, the more perfectly they manifest their peculiar properties; so that in every sense this assertion is either false or unintelligible.

With respect to zinc and cobalt, there is not the least foundation for suspecting, much less affirming, their existence in regulus of manganese, as they are never found even in the ore of manganese, except fortuitously; but, on the contrary, this ore is most frequently found without a particle of either; nor does the regulus shew any property that approximates it more to them than to other metallic substances, but, on the contrary, many that belong to no other, nor to any compound of any other metallic substances.

A P P E N D I X

APPENDIX III.

*Geological Observations.**Mountains:*

ELEVATIONS, consisting chiefly of clay, sand or gravel, are called *Hills*, those that consist chiefly of stone are by mineralogists called *Mountains*. As they are the chief repositories of minerals, and particularly of metallic ores, I shall here relate the most interesting observations relative to them that have occurred to me, or that have been made by others.

Mountains may be considered either with a view to their antiquity and origin, their height, or their structure.

Of the Antiquity and Origin of Mountains.

In this point of view mountains are divided into *primeval*, that is, of equal date with the formation of the globe, and secondary, or *alluvial*; some add even *tertiary*; but this distinction I think superfluous.

Among the primæval, those that consist of granite hold the first place. The highest mountains, and most extensive ridges in every

part of the globe, are granitical. Thus the *Alps* and *Pyrenæes* are the loftiest in *Europe*, and particularly such of them as consist of granite, the *Altaiſchan*, *Uralian* and *Caucasus* in *Asia*, and the *Andes* in *America*. From them the greatest rivers derive their origin. The highest of them never contain metallic ores, but some of the lower contain veins of copper or tin, as those of *Saxony*, *Sileſia* and *Cornwall*. The granitic stones next the ore always abound in mica; petrefactions are never found in them.

Many of the granite mountains of *Asia* and *America* form large plat-forms at about half their height, from which several lofty spires arise. No such plat-forms have been observed in the *Alps* or *Pyrenæes*.

That the formation of these mountains preceded that of vegetables and animals is justly inferred from their containing no organic remains either in the form of petrification or impression, from their bulk, extension and connection, which seem too considerable to be ascribed to subsequent causes, and from their use and necessity for the production of rivers, without which it is hard to suppose that the world had existed at any period since the creation of animals. Most naturalists are at present agreed that granites
were

were formed by crystallization: This operation probably took place after the formation of the atmosphere, (which in the history of the creation is called the firmament) and the gradual excavation of the bed of the ocean; soon after which, it is said, that by the command of God (that is, by virtue of the laws of nature which he established) *the dry land appeared*; for by means of the evaporation of part of the waters into the atmosphere, and the gradual retreat of the remainder, the various species of earths before dissolved or diffused through this mighty mass, were disposed to coalesce, and among these the *siliceous* must have been the first, as they are the least soluble: but as they have an affinity to other earths with which they were mixed, some of these must also have united with them in various proportions, and thus have formed in distinct masses the felt spar, shoerl and mica, which compose the granite. Calcareous earth enters very sparingly into the composition of this stone; but as it is found in shoerl, which is frequently a component part of granite, it follows that it must be one of the primitive earths, and not entirely derived from marine exuviae as many imagine. Quartz can never be supposed to be a product of fire, for in a very low heat it bursts, cracks, and loses its transparency, and in the highest we can produce, it is infusible;

so that in every essential point it is totally unlike to glass to which some have compared it. As granite contains earths of every genus, we may conclude that all the simple earths are coeval with the creation. This observation does not preclude further researches into their composition; for though water undoubtedly dates from the creation, yet some late experiments shew it to be a compound: their simplicity may be only relative to the present state of our knowledge.

Mountains, which consist of *lime-stone* or *marble* of a granular or scaly texture, and not disposed in strata, seem also to have preceded the creation of animals, for no organic traces are found in them. Also those that consist of stones of the *argillaceous* genus, and of the 6th compound species of the siliceous genus, seem to be primæval, as they contain no organic remains: these often consist of parallel strata of unequal thickness, and the lower are harder and less thick than the upper, whence the lower seem to have been first formed, and the upper latter. They are the principal seat of metallic substances, whose ores run across the strata in all directions; hence they are by the Germans called *Gang geburge*, and by the French *Montagnes à filons*. Coal is never found in them.

It is little to be doubted, but that submarine volcanos preceded not only the creation of animals, but also the separation of dry land from the waters, the Mosaic expression, *Let there be Light*, seems to me to denote the consequences of those laws of nature to which volcanos owe their origin. The specific gravity of the globe exceeds 3 or 4 times that of water, and consequently its proportion of earth is greater than that of water; but at the creation the mass of water as specifically lighter, lay for the most part at the surface, until by the excavation of the bed of the ocean, and by evaporation, it made way for the appearance of dry land. Hence the interior regions of the globe, were never so overwhelmed with water, but volcanos might be formed within them, as they are at this day under the sea. The flame of these fires being adapted to excite the sensation of light, sufficiently authorised Moses to call it by that name, and the period during which it existed by that of *Day*, in contradistinction to the period of darkness which preceded and succeeded it. Mr. *Giraud de Soulavie* has distinctly proved the existence of these primæval volcanos, in various parts of his *Natural History of the South of France*.

Alluvial mountains are evidently of posterior formation, as they contain petrefactions
and

and other vestiges of organic substances, they are always stratified.

The principal granitic ridges are flanked by argillaceous, as these are by alluvial mountains.

Of the height of Mountains.

There is no circumstance relating to mountains, that excites the surprise, or interests the curiosity of mankind to a greater degree than their height; hence many methods have been devised to determine it. The trigonometrical is the most antient, and in many cases exact, but it is often imperfect, and in some cases impracticable; the barometrical also remained for a long time imperfect, until the celebrated Mr. *De Luc*, with indefatigable industry, and uncommon sagacity, brought it to a degree of accuracy, scarce to be expected. Some improvements have lately been made in it by Sir *George Shuckburgh*, and the calculation has been rendered still more simple by Mr. *Magellan*.

In this method the elevation of mountains is determined by the different heights of 2 columns of mercury, one at the top and the other at the bottom of the mountain, the degree

gree of heat of each being equal, or reduced to an equality, and the common temperature of the atmosphere being given. Two barometers are therefore used, and each has a thermometer annexed to it. The degree of heat to which both barometers are reduced, is 55° of Fahrenheit, yet if either of the barometers be at 30 inches, and the thermometer attached to it at 55° , no reduction need be made in that barometer; but if either barometer be at 30, and the thermometer attached to it below 55° , we must add the expansion the mercury would have by the heat of 55° , or if it be above 55° we must subtract the excess of expansion it gains by that heat.* Now every degree of Fahrenheit produces an expansion, of, $\frac{1}{100304}$ of the barometrical inch, when the barometer is at 30, therefore when the thermometer is at n degrees below or above 55° we must add in the former, or subtract in the latter case, $\frac{1}{100304} n$ to, or from the barometrical height. But if the mercury in the barometers stand above or below 30 inches, then let the correction be found as if the mercury were at 30, and let it be denoted by c , the correction sought by x and the barometrical height b , then $\frac{bc}{30} = x$. The thermometers should go alike, or if not, the difference should be observed and subtracted.

* The fractions to be added or subtracted, are marked on a separate scale, called the scale of correction.

The barometrical heights, of both barometers being thus corrected, the logarithm of the number of inches at which the mercury in the upper stands, is to be subtracted from the logarithm of that of the lower; the difference between the 4 first decimal figures on the left gives *nearly* the number of fathoms, as that of the two last decimals does of the parts of a fathom between the upper and lower barometers, which being multiplied into 6, gives the number of feet and parts of a foot.

I said *nearly*, for this height is not exact, except when the mean temperature of the atmosphere is $31^{\circ},24$ of Fahrenheit.

The mean temperature of the atmosphere is the arithmetical mean between the degrees, marked by two *detached* thermometers, one above, and the other below, both being held for about an hour in the shade.

When this medium is $31^{\circ},24$, the above method is just, and requires no further correction, but if the medium exceeds, or falls short of $31^{\circ},24$ that difference must be found, suppose it = d .

The approximate height must now be corrected by multiplying it in feet, into the fraction $0,00243$, let the product = p , then
 pd

pd added to the approximate height, if the mean temperature be above 31°, 24, or subtracted from that height, if the mean temperature be below 31, 24 gives the true height.

The following example will make the calculation more intelligible, the instruments on the top of the mountain are denoted by *A*, and those at the bottom by *B*.

OBSERVATIONS.

Barometer A	-	-	25,19 Inches.
Its attached thermometer			46°
Detached thermometer A			39,5

Barometer B at the same time			29,4
Attached thermometer	-		50
Detached ditto	-	-	45°

CALCULATION.

Here the lower barometer stands below 30 inches, and its attached thermometer below 55° namely at 50. then $n=5$ and $,00304 \times 5 = ,01520$ this would be the correction to be added if the barometer were at 30, but as it is at 29,4 then

$$\frac{bc}{30} = \frac{,29,4 \times ,01520}{30} = \frac{,44688}{30} = ,01489 = x$$

which

which is to be added to 29,4 $\left. \begin{array}{r} 29,4000 \\ +,0148 \end{array} \right\} =$
29,415 its corrected height

Again the upper barometer is at 25,19 inches, and its attached thermometer at 46 then $n=9$. and $c=.02736$ and $\frac{b}{c} = \frac{25,19 \times .02736}{30} =$
 $.02297=x$ and $25,19 + .02297 = 25,21297$
or in round numbers 25,213 as its corrected height.

Now the logarithm of 29,415 is 1,468568,
and the log. of 25,213 is 1,401624, whose
difference is $\begin{array}{r} 4685,68 \\ - 4016,24 \\ \hline 669,44 \end{array}$

The difference of the 4 first figures on the left, gives the number of fathoms, and is therefore separated by a comma from the last, which gives the decimal parts of a fathom, and $669,44 \times 6 = 4016,664$ feet, this is the approximate height.

The mean temperature is next to be found. The detached thermometer *A* was at 39,5, and the detached thermometer *B* at 45, now then
39,5

$39,5 + 45 = 84,5$ and $\frac{84,5}{2} = 42,25$, which is therefore the mean temperature of the atmosphere; the difference between this and $31,24 = 11,01 = d$.

The fraction, $,00243$ is now to be multiplied into $4016,664$, the product is $9,7604$ which multiplied into $d = 107,462$, and as the mean temperature is above $31,24$. pd is to be added to the approximate height then $4016,66 + 107,46 = 4124,12$ feet, the true corrected height.

Some of the most remarkable mountains, whose heights have been taken with tolerable accuracy are,

IN AMERICA.

English feet above the level of the sea.

Chimborazo	-	-	-	20575,8 or 3,89 miles.
El Coraçon	-	-	-	15783
The town of Quito	-	-	-	9242

IN AFRICA.

Teneriffe	-	-	-	11022 De Borda 13 <i>Roz.</i>
Pico Ruiyo in Madeira	-	-	-	5141 <i>Phil. transf.</i> 1765.

IN

IN EUROPE.

Mont Blanc, highest of the Alps 15672 Sir G. Shuckburgh
Phil. tr. 1777.

Vesuvius in 1776	- -	3938	Saussure.
Ætna	- - - -	10954	
Canigou, one of the Pyrenees		9214	
St. Bartelemi in pays de Foix		7565	
Mont d'Or in Auvergne	- -	6696	
Puy de Dome	- - -	5221	
Hecla	- - - -	5000	Von Troil.

The height of the Asiatic mountains has never been accurately determined. Mr. *Bergman* remarks, that the sphericity of the earth is no more altered by the height of the highest mountain, than that of a globe of 2 feet in diameter, would be by an elevation of the size of a grain of sand.

The line of congelation in summer, under the Æquator, is at the height of 15400 feet; at the entrance of the temperate zone, 13428; on *Teneriffe*, in latitude 28, at about 1000; in *Auvergne*, in latitude 45, at 6740 nearly; with us, in latitude 52, it is probably at 5740. The greatest height hitherto ascended, is 15783 feet; in *Peru*, vegetation ceases at the height of 14697 feet, and on the *Alps*, at 9585, Mr. *Saussure* found the air less pure at 3834 feet; Mr. *D'Arcet* observed, that on
the

the *Pic de midi* (one of the Pyrenees, lower than *Conigou*) salt of tartar remained dry for an hour and a half, though it immediately moistened at the bottom of the mountain. The vapor of marine acid was also invisible on the summit. The electric and magnetic powers were as strong as on the plain. 8 Roz. 403.

Of the Structure of Mountains.

Mountains considered as to their structure, are divided into *intire*, *stratified*, and *confused*.

Intire mountains are formed of huge masses of stone, without any regular fissure, and mostly homogenous; they consist chiefly of granite, sometimes of gneiss, schistus, flagstone, sandstone, limestone, gypsum, porphyry, serpentine, or trapp. Some in *Sweden* and *Norway* consist of iron.

Stratified mountains are those whose mass is regularly divided by joints or fissures; these strata are considered in relation to the angle which their fissures make with the horizon and meridian, with respect to the former they are called horizontal, rising, or dipping. With regard to the latter, they are said to run to this or that point so many degrees;

they are most commonly parallel to each other, and rise or fall with the mountain.

The strata of which mountains consist, are either *homogeneous* or *heterogeneous*.

Homogenous stratified mountains consist chiefly of stones of the argillaceous genus, as shisti, hornstones, flagstones, or of the siliceous compound species of the siliceous genus, as gneiss, and metallic rock, or of both, the one behind the other. Sometimes of primæval limestone, that is, limestone of a granular or scaly texture, in which no animal vestiges appear. This limestone reposes on the argillaceous or siliceous strata; sometimes the argillaceous are covered with masses of granite, and sometimes with lava.

These mountains, as already observed, are the chief seat of metallic ores, particularly those of gneiss, metallic rock, and hornstone. When they are covered with limestone, the ore is generally between the limestone and the argillaceous stones. These ores run in veins and not in strata. The calcareous rarely contain any ore, when they do, it is either iron, copper, lead, or Mercury. Petrefactions

tions are found upon, but not in these mountains.

Heterogenous, or compound stratified mountains *, consist of alternate strata of various species of stones, earths or sands either of the calcareous or argillaceous genus, or both, or metallic ores, and sometimes lava, as toad-stone, &c. The lime-stone is always of the laminar, and not of the granular or scaly kind, and when it contains any ore, this is placed between its laminæ; it is very seldom that stones of the siliceous genus form any stratum in these mountains, except lavas; but the strata are frequently interrupted by siliceous masses; such as jasper, porphyry, granite, &c. these may be called *stops* †. Coal, bitumen, petrifications and organic impressions, are found in these mountains; also salts, calamine, gold in the sandy strata, iron in intire strata or nestways, copper in the strata, lead ore, singly or mixed with copper, (it sometimes shoots through the strata in small veins,) cobalt ore in the stops, pyrites every where; it sometimes constitutes whole strata; the matrixes of these ores are chiefly of the calcareous or barytic genera, rarely quartz, and never mica.

* *Flotzgebürge*.
sel. I am not acquainted with the correspondent English technical terms.

† *Klancken, kamme, Rücken Wecksel*.

There are other mountains analogous to these, which yet cannot properly be called stratified, as they consist only of three immense masses; the lowest granite, the middle of the argillaceous genus, and the uppermost of lime-stone. When they are metalliferous, as they generally are, the metallic ores are found in the argillaceous part, or between it and the calcareous; these ores form veins or bellies, and not strata; these may be called *triplicate* mountains.

Confused mountains; that is, of a confused or promiscuous structure, consist of stones of all sorts heaped together without any order; their interstices are filled with sand, clay and mica; they scarce ever contain any ore.

Of Volcanos.

Volcanos, or burning mountains, are peculiar to no climate, and have been observed in every quarter of the globe: they have no necessary or regular connection with other mountains, but they seem to have some with the sea, for they are generally placed in its neighbourhood. It is true that antient extinguished volcanos have lately been discovered in the inland parts of most countries; but this is one of the many proofs that the sea at some remote period covered those countries.

tries. Sub-marine volcanos have often been observed even in our own times.

These mountains are of all heights, some so low as 450 feet, as that in *Tanna**, but they generally form lofty spires, internally shaped like an inverted cone placed on a broader basis. This cone is called the crater of the volcano, as through it the lava generally passes, though sometimes it bursts from the sides, and even from the bottom of the mountain; sometimes the crater falls in and is effaced; sometimes in extinguished volcanos it is filled with water, and forms those lakes that are observed on the summit of some mountains.

Both the crater and basis of many volcanic mountains consist of lava either intire or decomposed, nearly as low as the level of the sea, but they finally rest either upon granite, as the volcanos of *Peru*, or on shistus, as the extinguished volcanos of *Hesse* and *Bohemia*, or on lime-stone, as those of *Silesia*, the *Vicentine Alps*, and *Vesuvius*. The decomposed and undecomposed lavas form irregular strata that are never parallel to each other. No ore is found in these mountains, except iron, of which lava contains from 20 to 25 per cent.

* *Foster*, 143.

and some detached fragments of copper, antimonial and arsenical ores.

If we consider the immense quantity of matter thrown up at different periods by volcanic mountains, without lessening their apparent bulk *, we must conclude the seat of these fires to be several miles, perhaps hundreds of miles, below the level of the sea; and as iron makes from $\frac{1}{7}$ to $\frac{1}{4}$ of all these ejections, we may infer that the interior parts of the earth consist chiefly of this metal, its ores, or stones that contain it, whose greater or lesser dephlogistication in different parts may be the cause of the variation of magnetic direction.

The origin of these fires is not easily accounted for. It is well known that martial pyrites, being moistened, will acquire heat; but that this heat should burst into actual flame, the concurrence of open air is absolutely requisite; however, if we suppose the heated pyrites to have been in contact with black wad and petrol, we may suppose the flame to arise, as we see it produced by art from the desiccation of that substance, and its mixture with the mineral oil. That ore when heated affords dephlogisticated air,

* Mr. Gerbard computes that *Vesuvius* has ejected from the year 79 to the year 1783, 309658161 cubic feet, *2 Mineral. Gesch.* §. 87.

of which a very small quantity is sufficient to produce flame: this flame once produced, may be supported by dephlogisticated air from other ores, which Dr. *Priestly* has shewn to afford it, and the phlogiston may be supplied by pyrites, bituminous shistus, bitumen and coal; marl, shistus, horn-stone, shoerl, with a further addition of iron from the pyrites, are the true sources of the melted matter or lava. The explosion and eruption of this melted matter proceeds, in all probability, from the access of a large quantity of water, which either enters through some crack in the bottom of the sea, or from sources in the earth; if the mass of water so admitted be sufficiently great, it will extinguish the subterraneous fire; if not, it will suddenly be converted into vapour, whose elastic force is known to be several thousand times greater than that of gunpowder; if the superincumbent weight be too great, it may cause earthquakes, but will propel the melted matter laterally towards the mouth of the volcano, where, meeting with least resistance, it will expel it, together with all the unmelted stony masses it meets in its passage. It is easy to conceive that before the dense melted matter is ejected, the dilated air of the volcano will first be forced out, and carry with it the ashes and looser stones adhering to the sides and crater of the volcano, as has been

observed, and elegantly described by our modern *Pliny* Sir *William Hamilton*.

The substances ejected by volcanos are, phlogisticated, fixed, and inflammable air, water, ashes, pumicestones, stones that have undergone no fusion, and lava.

The water proceeds partly from that contained in the volcano, partly from the condensed vapors, and partly perhaps from the intimate union of the phlogiston and dephlogisticated air; an union which some late experiments shew to be productive of water in certain circumstances. Part of the ashes is plentifully moistened with this water, and forms *tufa traafs*, &c.

Stones of all sorts and sizes, even of 10 feet in diameter, are projected by volcanos, and sometimes to great distances: hence probably those solitary masses of granite, which are sometimes met with in lime-stone countries.

Lavas, in their passage through the volcano and its caverns, and during their flowing, necessarily involve various sorts of stone, which are not therefore products of fire, though found in lava; such as quartz, spar, shoerl, &c. and thus various porphyries and
pudding-

pudding-stones are found, which have lava for their ground.

Basaltes, and in many instances shoerl, seem to me to owe their origin both to fire and water : they seem to have been at first a lava, but this lava, while in a liquid state being immersed in water, was so diffused or dissolved in it with the assistance of heat, as to crystallize when cold, or coalesce into regular forms. That basaltes is not the result of mere fusion appears by a comparison of its form with its texture ; its form, it being crystallized, should be the effect of a thin fusion, but in that case its texture should be glassy ; whereas it is merely earthy and devoid of cavities. Hence we may understand how it comes to pass that lava perfectly vitrified, and even water, are sometimes found inclosed in basaltes. *Mon. Mineral.* 511. *Von Troil,* 285.

The immense masses of lava ejected by volcanos, presenting but a relatively small surface to the atmosphere, are many years in cooling, and many hundreds of years are required for their decomposition ; this decomposition is quicker or slower as they have been more or less perfectly melted. According to the observations of Sir *William Hamilton*, the lava of *Vesuvius* forms one or two feet of mould in 1000 years ; this bed of mould
being

being afterwards covered with fresh lava, and this, after mouldering by that of still latter eruptions, affords some ground for calculating the age of the volcano at least within certain limits.

The beds of lava are deepest and narrowest in the proximity of the crater, and broader and shallower as they are more distant, unless some valley intervenes; pumicestone and ashes lie still more distant. From these observations extinguished volcanos are traced. Many excellent investigations of this sort may be seen in Mr. *Soulavie's* history of the south of *France*.

Basaltic mountains (common in *Sweden*) seem to owe their origin to sub-marine volcanos.

Petrifications.

The most remarkable observations relative to petrifications are,

1st. That those of shells are found on or near the surface of the earth; those of fish deeper, and those of wood deepest. Shells in *specie* are found in immense quantities at considerable depths.

2^{dly}. That those organic substances that resist

first putrefaction most are frequently found petrified; such as shells and the harder species of woods: on the contrary, those that are aptest to putrefy are rarely found petrified, as fish, and the softer parts of animals, &c.

3^{dly}. That they are most commonly found in strata of marl, chalk, lime-stone or clay, seldom in sand-stone, still more rarely in gypsum, but never in gneiss, granite, basaltes or shoerl; but they sometimes occur among pyrites, and ores of iron, copper and silver, and almost always consist of that species of earth, stone, or other mineral that surrounds them, sometimes of flint, agate, or carnelian.

4^{thly}. That they are found in climates where their originals could not have existed.

5^{thly}. That those found in slate or clay are compressed and flattened.

Of Metallic Ores.

Iron ore is the only one that forms intire mountains, all other ores form but an inconsiderable part of the mountain in which they are found.

Ores either run parallel to the stony strata,
or

or run across them in all directions; these last are called *veins*.

The course of veins, with relation to the meridian, is called their *direction*, and with relation to the horizon is called their *inclination*.

Their direction, in the language of miners, is denoted by *hours*; the horizontal circle being divided into twice 12 hours, 12 from south to north, and 12 from north to south: east and west directions are therefore denoted by 6 o'clock.

Inconsiderable veins that diverge from the principal are called *slips*; considerable masses of ore that have no great length are called *bellies* or *stock-works*; so are also accumulated veins or thick bodies of ore formed by the junction of several veins.

The stones which fill the cavities that form the veins are called the *matrix* (gang) of the ore; the rocks that lie over the veins are called the *roof*; those that lie under them the *floor*, and by some the *badging*; the *matrix* is almost always a finer species of stone than the surrounding rocks, though of the same genus; even the rocks themselves are finer grained as they approach the vein.

There

There is no matrix peculiarly appropriated to any metal; it has only been remarked, that tin is generally found among stones of the siliceous genus, and lead very frequently among those of the calcareous.

There is no certain sign from which the existence of an ore in any mountain may be inferred, except the vestiges of it in the beds of torrents or mineral waters, and the structure of the mountain itself, of which enough has been already said.

Of Hot Springs.

Mr. *Tiffington* has remarked, that waters flowing through a blue marl filled with nodules of pyrites are warm; Mr. *Guettard* has also observed, that all the hot mineral springs of *France* flow from shistus: hence there is no occasion to derive their heat from any subterraneous volcano.

T A B L E

TABLE I.

The Quantity of Metal in a Reguline State afforded by 100 Grains of different Metallic Calces, and to which consequently they are respectively equivalent.

100 Grains	- - - - -	Grains.
Brown calx of iron afford of		
regulus	- - - from 79	to 89 grs.
Red ditto	- - - from 71,4	to 78
Brown calx of copper	from 84	to 86,5
Minium	- - - - -	89
Calx of tin	- - - - -	96
Precipitate per fe	- - -	92
Flowers of zinc	- - -	85,5
Calx of bismuth	- - -	98
Grey calx of antimony		96
White calx of manganese		54

Hence the quantity of calx, which 100 parts of any of these metals would afford, is easily found; thus 100 gr. of lead would afford 113 of minium for $\frac{100}{89}$. $100 : : 100$
113.

TABLE

T A B L E II.

Of the Weight and Colour of Metallic and Earthy Precipitates, extracted with some Alterations and Additions from the 2d vol. of Mr. Bergman.

100 Grains.	Precipitated by	Weight.	Colour.
GOLD.	Aerated Min. Alkali	106 Gr.	Yellowish.
	Caustic Ditto	110	Darker, retains more acid than the former.
	Prussian	-	Yellowish or bluish from Iron, not total.
SILVER. In Nitrous Acid	Aerated, &c.	129	White.
	Caustic	112	White.
	Prussian	145	Brick colour, or if dilute, flesh colour.
	Marine Acid	133	White cloud or clots.
COPPER. Nitrous Acid	Aerated	194	Bluish green.
	Caustic	158	Greyish brown.
	Prussian	530	Dark red.
IRON. Vitriolic or Marine Acid	Aerated	225	Greenish brown, and soon after yellowish.
	Caustic	170	Darker brown.
	Prussian	590	Blue.

T A B L E II. Continued.

100 Grains.	Precipitated by	Weight.	Colour.
TIN.			
Aqua Regia, or	Aerated - - -	131	White.
Marine Acid	Caustic - - -	130	White.
	Prussian - - -	250	Dark green, and soon after blue.
LEAD.			
Nitrous Acid	Aerated - - -	132	White.
	Caustic - - -	116	White.
	Prussian - - -		Greenish yellow, and after some time white.
	Vitriolic Acid - -	143	Or if well washed, 137. White grains.
MERCURY.			
Nitrous Acid	Aerated - - -	110	Brick colour.
	Caustic - - -	104	Yellower.
	Prussian - - -		White and yellow, with spots of green.
	Vitriolic Acid - -	130	Or 119 if washed. White.
ZINC.			
Nitrous Acid	Aerated - - -	193	} Dull white.
	Caustic - - -	161	
	Prussian - - -	495	
			Reddish yellow, and after sometime whitish yellow.
Regulus of Antimony.			
	Aerated - - -	140	} Dull white.
	Caustic - - -	138	
	Prussian - - -	138	
			Blue, easily re-dissolved by excess, and then green.

BISMUTH. Nitrous Acid	Aerated	- - -	130	} White. Reddish yellow. White.
	Caustic	- - -	125	
	Prussian	- - -	180	
	Water	- - -	113	
NICKEL. Nitrous Acid	Aerated	- - -	135	} Whitish green. Dirty reddish yellow, or red and greenish yellow.
	Caustic	- - -	128	
	Prussian	- - -	250	
COBALT. Nitrous Acid	Aerated Alkali	- - -	160	} Greenish pale red. Blue, greyer than that of iron.
	Caustic	- - -	140	
	Prussian	- - -	142	
ARSENIC. Marine Acid, or Aqua Regia	Aerated	- - -		} White, imperfect. Green and yellow mixed.
	Caustic	- - -		
	Prussian	- - -	180	
MANGANESE. Nitrous Acid	Aerated	- - -	180	} Brownish red when dephlogd-or white if phlogificated Dirty bluish grey, and after some time, brownish grey.
	Caustic	- - -	168	
	Prussian	- - -	150	
EARTHS. Barytes Nitrous Acid Marine Acetous	} Prussian		150	} Reddish white. Greenish white. Yellowish and greenish white.

T A B L E II. Continued.

Colour.

100 Grains.	Precipitated by	Weigh.
Pure Lime	Aerated Alkali -	181,8
	Caustic - - -	130
Magnesia	Aerated - - -	222
	Caustic - - -	118
	Caustic Vol. - -	110

100 Grains regulus of antimony, dephlogificated by nitrous acid, weigh 138 grains.

100 Grains tin, dephlogificated by nitrous acid, weigh 140 grains.

REMARKS.

The precipitates are generally supposed to be well washed in distilled water, and dried in a heat of 212 of Fahrenheit, to which they are exposed for 10 minutes.

The precipitate of bismuth by *Prussian* alkali, is re-dissoluble in hot nitrous acid. That of lead is not.

The quantity of *Prussian* alkali necessary to precipitate barytes from the acetous acid, is to that necessary to precipitate iron from the marine, as 1 to 14 nearly.

T A B L E III.

*Of the Proportion of Ingredients in Earths and Stones.**Calcareous Genus.*

100 Parts.	Calcar.	Argill.	Silex.	Magn.	Wat.	Iron.
Calcareous Spar	55	—	—	—	11	— ^a
Gypsum	32	—	—	—	38	— ^b
Fluor	57	—	—	—	—	— ^c
Tungsten	50	—	—	—	—	— ^d
Compound Spar	60	—	—	35	—	5 ^e
Cruetzenwald Stone	75	—	—	12	—	3 ^f
Calcareous Marle	50 to 75	20 to 30	20 to 30	—	—	— ^g
Margodes	50	32	15	—	—	2
Stellated Spar	66	—	30	—	—	3
Calcareous Grit or Sand Stone	50	—	—	—	—	— ^b
Swine Stone	95	—	—	—	—	— ⁱ
Pyritaceous Limeft.	75	14	—	—	—	4 ^k
Martial Tungsten	—	—	—	—	—	50 ^l

^a And 34 Fixed Air. ^b And 30 Vitriolic Acid. ^c 43 Acid and Water. ^d 50 Acid and Iron, ^e Both Earths mild. ^f Ditto. ^g And Water. ^h Or more. Remainder, Silex, Argill, and Iron. ⁱ And Petrol, remainder, Argill and Iron. ^k And 7 Quartz and Sulphur, that is, 25 Pyrites. ^l By the dry way only 30, and 50 Tungsten.

Barytic Genus.

100 Parts.

Mild Barytes 78 Earth, 20 Fixed Air, 2 Barofelenite.
 Barofelenite 84 Earth, 13 Vitriolic Acid, and 3 Water.
 Hepatic Stone 33 Barofelenite, 33 Silex, 22 Allum, 7 Gypsum, 5 Petrol.

Muriatic

404 T A B L E I I I . *continued.*

Muriatic Genus.

100 Parts.	Silex.	Calc.	Magnesia.	Argill.	Water.	Iron.
Mild magnesia - - -	—	—	48	—	22	—*
Keffekil - - -	50	—	50	—	—	—
Steatites - - -	80	—	17	2	—	1
Argillaceous steatites	72	—	17	11	—	—
Chalk of Briançon -	70	—	17	11	—	—†
Soap Rock - - -	70	—	17	13	—	—
Asbestos - - -	63	11	20	4	—	2‡
Martial abestos - -	62	12	13,7	1,7	—	10,6
Suber montanum - -	59	11	24	2,4	—	3,6§
Amianthus - - -	64	6,9	18,6	3,3	—	1,2§
Serpentine - - -	45	—	23	18	12	3
Talc Muscovy - - -	50	—	45	5	—	—
Talc Venetian - - -	- a larger portion of argill and smaller of magnesia.					

Note. The magnesia and calcareous earths are in a mild state in all the above stones.

* At a medium and 30 fixed air. † And 2 of talc. ‡ At a medium.
 § At a medium. ¶ And 6 barytes.

Argillaceous Genus.

	Silex.	Argill.	Calcareous	Magnesia.	Iron.	Water.
Pure clay dry - - -	63	37*	—	—	—	—
Argillaceous marl dry	46	27	25 †	—	—	—
Fuller's earth - -	53	18	5	3	4	17‡
Poluzzolana - - -	57	20	6	—	20	—
Tripoli - - -	90	7	—	—	3	—
Pure mica - - -	38	28	—	20	14 ¶	—
Martial mica - - -	34,5	25,5	—	18	22	—
Roof slate or shistus	46	26	4 mild	8 mild	14	—
Flagst. or argill. shist.	36	56	—	—	4	—
Horn-stone - - -	37	22	2	16	23	—
Killas - - -	60	25	—	9	6	—
Toadstone - - -	63	14	7	—	16	—
Zeolyte - - -	60	20	8	—	—	12§
Pitch-stone - - -	65	16	—	—	5	14 ¶
Grontsen - - -	Horn-stone and mica, or horn-stone and shorl.					
Stellsten - - -	Mica, quartz and argill.					
Binda - - -	Horn-stone, mica, shorl, quartz, and pyrites.					
Grovan - - -	Argill, mica and quartz.					

* At a medium when perfectly dry, 63 siliceous. † Mild at a medium.
 ‡ And marine acid at a medium. ¶ White calx of iron.
 § At a medium. ¶ And air.

TABLE III. continued.

405

100 Parts	Siliceous Genus.				
	Silex.	Argill.	Calcar.	Magn.	Iron.
Crystal	93	6	2	—	—
Flint	80	18	2	—	—
Petrofiliex	72	22	6	—	—
Jasper	75	10	—	—	3
Chalcedonian	84	16	—	—	—
Ruby	39	40	mild 9	—	10
Topaz	39	46	ditto 8	—	6
Hyacinth	25	40	dit. 20	—	13
Emerald	24	60	8	—	6
Sapphire	35	58	5	—	2
Chrysoprasium	98	—	1,7	1,2	0,4 ^a
Lapis lazuli	—	—	—	—	— ^b
Felspar	67	14	—	8	— ^c
Vesuvian garnet	55	39	6	—	—
Garnet	48	30	12	—	10
Martial Garnet	43,6	27,6	10	—	19
Shoerl transparent	48	40	5	1	5
Shoerl Black	58	27	5	1	5
Bar shoerl	61,6	6,6	21,6	5	1,6 ^d
Tourmaline	37	45	13	—	5 ^e
Basaltes	52	15	8	2	25
Rowley ragg	47,5	32,5	—	—	20
Comp. and cellular lava	47	30	5	—	18
Vitreous ditto	49	35	4	—	12
Another from Lipari	69	22	—	—	9
Black agate of Iceland	—	—	—	—	—
nearly as the above	—	—	—	—	—
Pumice stone	84 or 90	—	—	6 to 15	— ^f
Martial muriatic spar	50	—	—	30 mild	20 ^g
Turkey stone	70	5	mild 25	—	— ^h
Ragg stone	70	5	dit. 20	—	5 ⁱ
Siliceous grit with cal-	62,5	—	d ^o 37,8	—	—
careous cement	—	—	—	—	—
Siliceous ditto with ar-	77	20	—	—	3 ^k
gillaceous cement	—	—	—	—	—
Ditto with ferruginous	80	5	—	—	15 ^l
cement	—	—	—	—	—

a 0,6 copper, and sparry acid. believe.

c 11 Ponderous.

f Remainder calcareous.

i As I believe.

k As I believe.

8 80 martial fluor, 20 gypsum, as I believe.

u 5 water.

g As I believe.

l As I believe.

e At a medium.

h As I believe.

406 T A B L E III. *continued.*

Granite	- - -	{ Quartz, felt spar and mica. Quartz, felt spar and shoerl.
Stellsten	- - -	{ Quartz and mica.
Granitello	- - -	{ Quartz and mica.
Rapakivi	- - -	{ Felt spar and mica.
Granitone	- - -	{ Felt spar and mica.
Murksten	- - -	{ Quartz, garnet and mica.
Norka	- - -	{ Quartz, garnet and mica.
Porphyry	- - -	{ Jasper, chert, lava, shoerl containing quartz, felt spar, shoerl, mica, or serpentine in a crystalline form.
Pudding stone	- - -	{ Jasper, chert, siliceous grit, or lava, containing pebbles of an oval form
Siliceous breccias	- - -	{ The same ground and contents, but in angular forms.
		{ Quartz, mica, steatites.
		{ Quartz, mica, serpentine.
Gneifs	- - -	{ Quartz, mica, shoerl, steatites, or soap rock.
		{ Quartz, felt spar, mica, serpentine.
Amygdaloides	- - -	{ Jasper, or chert, containing spar or serpentine.
Metallic rock of Born	- - -	{ Quartz, clay and steatites, and felt spar sometimes.
Variolite	- - -	{ Serpentine, containing various stones.

Proportion of Ingredients in Natural Salts.

	Acids	Alka.	Earth	Water	
Tartar vitriolate	31	63	—	6	
Glauber's salt -	14	22	—	64	
Vitriolic ammon.	42	40	—	18	
Epsom -	24	—	19	57	
Alum -	24	—	18	58	
Vitriol of iron -	20	—	—	55	25 iron.
Ditto of copper -	30	—	—	43	27 copper.
Ditto of zinc -	22	—	—	58	20 zinc.
Nitre -	30	63	—	7	
Cubic nitre -	29	50	—	21	
Nitrous ammon.	46	40	—	14	
Nitrous felenite -	33	—	32	35	
Ditto Epsom -	36	—	27	37	
Salt of Silvius -	30	63	—	7	
Common salt -	33	50	—	17	
Sal. ammoniac -	52	40	—	8	
Marine felenite -	42	—	38	20	
Borax purified -	34	17	—	47	

Inflammable.

Hepatic air—100 cubic inches of it united to water may contain 8 of sulphur.

Sulphur—60 acid and 40 of phlogiston.

Proportion of Ingredients in Metallic Ores.

100 Parts. *Gold.*

Ore of *Adelfors* or *Norway*—99,59 martial pyrites 0,41 gold.

— of *Salzburg* in *Tyrole*— $\frac{948}{1000}$ arsenical pyrites, and, 052 of gold.

— of *Nagaya*—99 pyrites, galena and silver, 0,83 of gold.

Gold sand of *Africa*—0,22 at most.

100 Parts. *Silver.*

Vitreous ore—25 sulphur, and 75 of silver.

Slightly arsenicated at *Quadanal-canal*—10 arsenic, and 90 of silver.

— superarsenicated at ditto—ditto from 4 to 6 ozs. of silver per quintal.

Red ore—31 realgar, 8 sulphur, and 60 silver generally.

Black ore solid—40 sulphur, arsenic, and pyrites, and 60 silver.

Black

Black ore loose—75 sulphur and pyrites, and 25 silver at most.

Arsenico-martial ore—from 90 to 99 iron, and arsenic, and from 10 to 1 of silver.

White ore—from 70 to 90 of sulphurated copper, arsenic, and iron, and from 10 to 30 of silver.

Grey ore—from 12 to 24 of copper, from 1 to 12 of silver, and the remainder sulphur, arsenic, and a little iron.

Brown ore—mostly copper, sulphur, arsenic, a little regulus of antimony and iron, and from 1 to 5 per cent. of silver.

Plumose ore—pyrites, arsenic, antimony, and about 1 per cent. of silver.

Cobaltic ore—sulphur, arsenic, cobalt, iron, and from 40 to 50 per cent. of silver.

Vitriolic and marine silver—about 70 of silver.

100 Parts. *Copper.*

Red calx of copper—26 fixed air, 1 water, 73 copper.

Brownish red—pyrites, and from 20 to 50 of copper.

Malachite—29 aerial acid and water, and 71 of copper.

Mountain green—22 aerial acid, 6 water, and 72 of copper.

Mountain blue—29 aerial acid, 2 water, and 69 of copper.

Vitreous

Vitreous copper ore—10 or 12 sulphur, and 90 of copper.

Azure ore—20 to 30 iron, from 40 to 60 of copper, the remainder sulphur.

Yellow copper ore—pyrites, sulphur, and from 4 to 30 parts of copper.

Grey copper ore—arsenic, pyrites, from 35 to 60 copper, and a little silver.

Blende copper ore—pyrites, pseudo galena, from 18 to 30 copper.

Schistose copper ore—schistus, sulphur, from 6 to 10 of copper.

100 Parts.

Iron.

Steel ore—from 60 to 80 iron.

Black eisen rahn—74 plumbago, 26 iron.

Sparry iron ore—38 calcareous earth, 24 manganese, and 38 iron.

Flos ferri—65 calcareous earth, and 35 calx of iron.

Magnetic sand of Virginia—about 50 of iron.

Hematites—from 40 to 80 of iron.

Grey iron ore—siderite, and from 40 to 66 of iron.

Highland argillaceous ore—from 30 to 66 of iron.

Ditto swampy—siderite, and 36 of iron.

Siliceous ore—25 to 30 of iron.

100 Parts.

Tin.

Black tin ore—80 tin, some iron.

Red ditto—more of iron than of tin.

Sulphurated tin—40 per cent. sulphur, a little copper, the remainder tin.

100 Parts.

Lead.

White lead ore—a little iron, argill or calcareous earth, 80 to 90 of tin.

Red ditto—more iron, argill, 80 or 90 of lead.

Green ditto—still more iron, seldom copper.

Bluish ditto—a little copper.

Vitriol of ditto—about 70 of lead.

Galena—from 15 to 25 of sulphur, from 0,01 to 1,5 or 2 of silver, from 60 to 85 of lead, besides quartz and iron.

Antimonial lead ore—antimony, from 0,08 to 0,16 silver, and from 40 to 50 of lead.

Pyritous lead ore—pyrites, 18 to 20 of lead.

Red lead spar—realgar, a little silver, and 43 of lead.

100 Parts. *Mercury.*

Native calx of mercury—9 fixed air, and 91 mercury.

Vitriol and marine salts of ditto—About 70 mercury.

Cinnabar—20 Sulphur, and 80 mercury.

Pyritous ore of mercury—Cobalt, arsenic, pyrites, 1 of mercury.

100 Parts. *Zinc.*

Vitreous Ore, Zinc, Spar—28 Aerial acid, 6 water, 1 iron, and 65 calx of zinc.

Tutanego—Iron, argill, and from 60 to 90 of zinc.

Calamine—Iron, clay, rarely calcareous earth or lead, 30 to 84 calx of ditto.

Zeolytic ore—Quartz, water, and about 36 calx of zinc.

Blende, psedogalena blue—8 iron, 4 copper, 26 fulphur, 4 water, 6 filex, and 52 zinc.

Ditto black—1 Arsenic, 9 iron, 6 lead, 29 fulphur, 6 water, 4 filex, and 45 zinc.

Ditto red—5 Iron, 17 fulphur, 5 water, 5 argill, 24 quartz, and 44 zinc.

Ditto, phosphoric—5 Iron, 20 fulphur, 4 sparry acid, 6 water, 1 filex, and 64 zinc.

Ditto grey—Galena, petrol, fulphur, 24 zinc.

100 Parts *Regulus of Antimony.*

Antimony—26 Sulphur, and 74 regulus.

Arsenicated ditto—The same as the plumose silver ore.

100 Parts *Regulus of Arsenic.*

Orpiment—10 Sulphur, and 90 arsenic.

Realgar—16 Sulphur, and 84 arsenic.

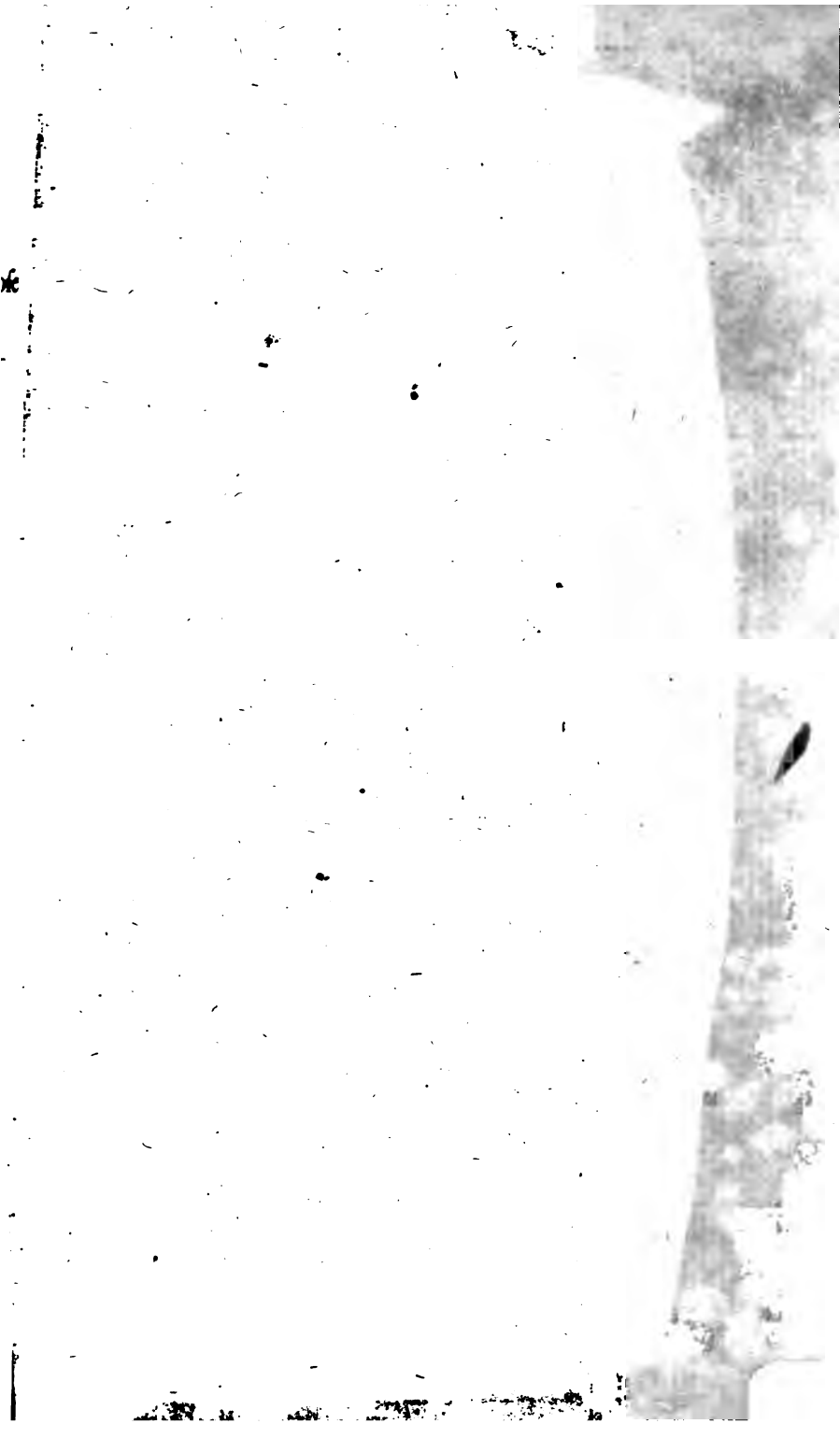
100 Parts. *Manganese.*

Sparry iron ore—50 Calcareous earth, 22 iron, and 28 calx of manganese.

100 Parts.

Molybdena—45 Acid, 55 sulphur.

F I N I S.





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